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Flat-tailed Horned Lizard (*Phrynosoma mcallii*) Monitoring Report

Bureau of Land Management
April 2003

Gavin Wright and Tyler Grant

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Abstract

Monitoring of the flat-tailed horned lizard (Phrynosoma mcallii) (FTHL) consisted of five projects in the field season of 2002:

1) A mark/recapture population estimate in the Yuha Management Area,
2) an attempted mark/recapture population estimate in the Imperial Sand Dunes Recreation Area,
3) twelve triangular transects in the eastern Yuha to record scat, FTHLs and vehicle routes,
4) the creation of a GIS generated map of all historic flat-tailed horned lizard sightings in Imperial and San Diego Counties,
5) and the completion of vehicle impact monitoring in the Yuha Management Area.

FTHLs were marked and recaptured on twelve plots in the Yuha Basin of Imperial County, California during the summer of 2002. The overall population estimate for the area was 32,071 lizards (95% confidence interval: 25,319 – 38,737) or 1.3 lizards per hectare (0.5 lizards per acre).

Sand coverage and lizard scat were the only variables significantly ($p <. 05$) correlated with population size ($r=.616$, $r^2=.38$, two-tailed $p=.032$ and $r=.695$, $r^{2=}.483$, two-tailed $p=0.012$, respectively). Plots with greater than 44% sand coverage ($n = 6$) had 5.6 times as many lizards as those with less than 44% sand coverage ($n = 6$, $p = .006$), while plots with less than 9% vehicle track coverage had 3.5 time as many lizards ($p =.05$). Neither vehicle track coverage nor number of vehicle routes and roads were significantly correlated with lizard numbers ($r= -.325$, $r^2=.105$, $p=.303$ and $r=-.422$, $r^2=.178$, $p=.172$, respectively).

Eleven randomly selected mark recapture plots were surveyed for flat-tails in the Algodones Dunes (5 in the Open Area, 6 in the Wilderness). More lizards were found in the Wilderness (.5/plot) than in the Open Area (0/plot) ($p = .07$). Densities in the Algodones Dunes are apparently very low, averaging only 0.03 flat-tails detected per hectare (0.01/acre). Actual densities may be higher if lizards were undetected.

The rate that FTHLs were detected from 1979 to 2002 in the eastern Yuha Desert on triangular FTHL transect surveys did not have a significant trend ($p = 0.51$), however scat detected per hour declined at a highly significant rate during the same period ($p = .007$) while the percentage of transects with scat or lizards declined at a rate approaching the .05 significance level ($p = .07$). The number of vehicle routes in the eastern Yuha declined by 45% from 2001 to 2002 probably due to unusually strong spring sandstorms and changes in Border Patrol practices.

Compilation of FTHL sightings in Imperial and San Diego Counties since 1978 demonstrated that the lizard's range extends from the Borrego Badlands to the Pilot Knob Mesa east of the Algodones Dunes. Over 30 sightings were recorded from the Dunes.

Impact surveys of the entire Yuha Management Area from 2001 – 2002 revealed that 8.5% of the surface had vehicle tracks on it (95% confidence interval: 6.1% – 11.1%, $n = 31$). The severest impacts were found along State Highway 98 where surface impacts exceeded 20% in several cases.

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Introduction

The FTHL (*Phrynosoma mcallii*) has the most restricted range of any species of horned lizard in the United States and much of its habitat has been converted to agriculture, golf courses, urban development or covered by the Salton Sea. Much of the remaining habitat is impacted by mining, geothermal development, immigration, border patrols, power lines, exotic plants, roads and off-road vehicle traffic. In the past this species has been difficult to enumerate due to its crypticity and relative rarity. This report presents the first successful attempt to quantify the number of FTHLs over a large area, as well as other data relevant to the conservation of the species. Such estimates are essential to understand the status of the species and plan for its conservation. Additional analyses of population densities in relation to various environmental factors are presented.

The El Centro Field Office of the Bureau of Land Management (BLM) has monitored the FTHL since 1978. The monitoring method employed until the summer of 2002 involved the counting of scat and lizards along triangular transects. The method was crude, didn't give the actual population size and had low sensitivity to changes in the population size. In the summer of 2001 a pilot study explored the feasibility of mark-recapture sampling to determine population density of this lizard. The pilot study was moderately successful and for the summer of 2002 mark-recapture plots were established in the Yuha Basin Management Area (MA) (figures 1 and 2) designated by the Flat-tailed Horned Lizard Rangewide Management Strategy (Foreman, 1997). This MA is one of the key areas for the species and has a relatively high level of human impacts. For these reasons it was selected for the survey. In addition to determining the number of FTHLs in the MA, habitat data were collected to better facilitate understanding of factors affecting the species abundance. In addition to the mark-recapture study, twelve 2.5 mile long transects were walked in the eastern portion of the MA to determine the relative rate at which the lizard and its sign were encountered and to compare these results with transect data from previous years.

In addition to the Yuha Basin, mark-recapture plots were surveyed at the Algodones Dunes. This survey had two purposes: 1) to determine the approximate densities at which the species occurs in the Dunes and 2) to determine if a difference in density of the species exists between the Open and Wilderness Areas of the Dunes. Some portions of the Algodones Dunes receive significant off-highway vehicle (OHV) impacts and the Bureau wishes to better understand the extent to which such impacts may affect the flat-tailed horned lizard.

A Geographic Information Systems (GIS) map was created showing all locations of FTHLs. These data provide a valuable record of both species recent and former distribution. Another map showing the level of vehicle impacts in the Yuha Desert was created.

The work completed during the 2002 field season should allow for better management of the species and its habitat in the future.

Methods

Mark-Recapture Plots in the Yuha Basin Management Area

Plots were chosen from the Yuha Basin Management Area (MA) designated in the Flat-tailed Horned Lizard Rangewide Management Strategy (Foreman, 1997). One private section was excluded from the area sampled because access could not be obtained. The Yuha was chosen because previous monitoring showed most evidence of a decline in population among the three Management Areas (figure 1) managed by the BLM, El Centro Field Office (Wright, 2002). In addition, vehicle routes had increased in this area since the early 90's and it is the smallest of the three MA's managed by BLM El Centro. Four plots were chosen with randomly generated Universal Transverse Mercator (UTM) coordinates from 3 strata divided based on general substrate type. The three strata were the fine sandy eastern Yuha (9280 ha, 38.0%), the rocky northwestern badlands (8203 ha, 33.6%) and the coarser, gravelly southwestern Yuha (6907 ha, 28.3%). Since the southwestern stratum is smaller than the other two, it is more intensively sampled than the other two strata, however given the constraints of a small sample size, the plots should give a representative and unbiased sample of the MA. Figure 1 shows the location of the Yuha Basin MA within Imperial County, CA. Figure 2 shows the locations of the 12 plots and 3 strata in the Yuha MA.

Plots in the Yuha were surveyed from June 6, 2002 to August 23, 2002. Plots were 200m by 200m (4 ha). One day was taken to delineate the plots with pin flags. The plot was divided into ~10m wide lanes to ensure even coverage. Visibility is better with the sun to either side than behind or in front, so lanes were marked and walked from north to south or south to north. Two to four people walked up and down the lanes looking for lizards, taking care to search the whole plot thoroughly. Technicians began searching as soon as it was light enough to see, varying from 5:15 am to 6:00 am as the days got shorter. The entire plot was searched in a morning and the technicians tried to time it so they finished before temperatures got too hot for the FTHLs to be on the surface. Search time varied from ~2 to ~4 hours. Plots were searched 4-8 days, depending on how many FTHLs were being found and the recapture rate.

When a lizard was found, it was captured and various measurements were taken including snout-vent length, weight, lizard temperature, surface temperature, air temperature 1 cm above the surface, GPS coordinates, time, and the slope and aspect of where the lizard was sitting (unless it was first seen running). Also recorded were observations such as gender, if a scat was present in their digestive system just above the pelvis (these scat are easy to feel and if present, indicate FTHLs are feeding), if females were gravid, the substrate the lizard was on, who found the lizard and if it was a recapture. Each lizard was marked with a black Sharpie (Sharpie Corporation) marker with a unique number. Additional data collected while walking the plot were information such as anthills seen, sets of flattail tracks seen, other FTHLs seen and horned lizard scat seen. Anthill data was subsequently not analyzed because it was determined to be inaccurate. This inaccuracy was created by all the distractions of looking for other habitat features.

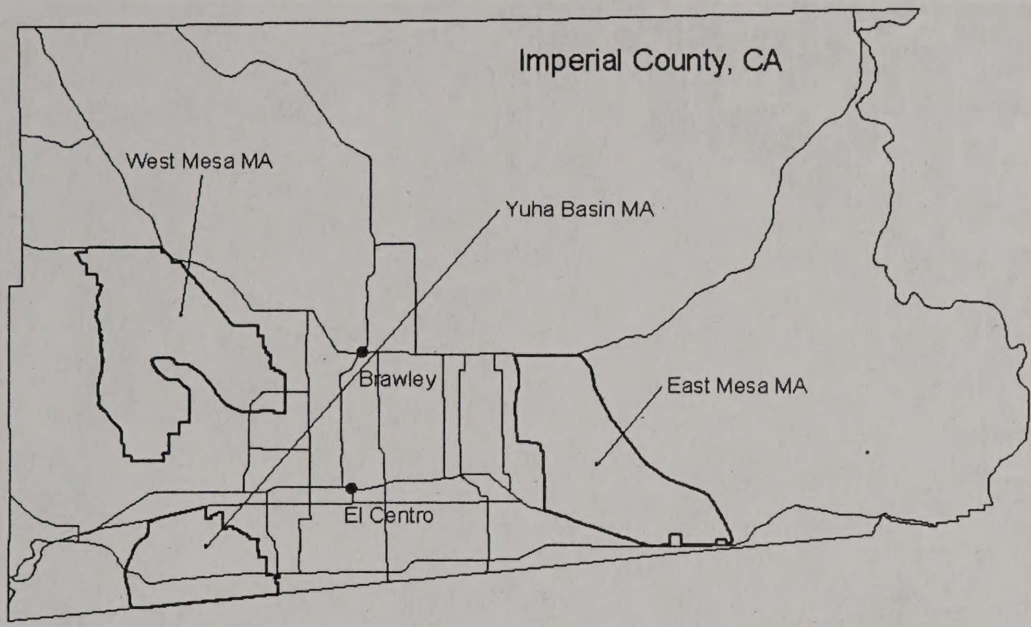

Figure. 1. Vicinity Map of Yuha Basin MA, Showing its Location in Southeastern California. Imperial County, CA. 2003.

We analyzed the mark-recapture results with the computer program MARK (White and Burnham, 1999), which gave a 95% confidence interval estimate of the population using each plot. The population size calculated by MARK for a plot can't simply be divided by 4 hectares to get a density estimate (Otis et al., 1978). More lizards use the plot over time than are on the plot at any single time. In other words, many home ranges are only partially in the plot. To calculate density, a boundary strip of half the size of the average home range of the lizards using the plot is added to the perimeter of the plot and that larger area is used for the density calculations (Otis et al., 1978). Unfortunately home range size for the flat-tailed horned lizards varies according to habitat, gender, size, density of lizards, how wet the year was and usually how long you follow the lizard (Young, 2000; Setser, 2001; Young, pers. comm.; Setser, pers. comm.).

We had two options to calculate a width for a density strip: use home range estimates from other studies or use the Mean Maximum Distance Moved (MMDM) method (Wilson and Anderson, 1985). We chose to use the MMDM because it is derived from our own data and not from a study of a different time and place. Wilson and Anderson (1985) found MMDM to be much more accurate than a "naïve" estimate (without a boundary strip). The MMDM across all 12 of our plots was 33.6 m. This corresponds to an effective search area of 267.2m x 267.2m or 7.14 ha. This number also agrees well with our other values of 45m and 22m calculated for adults and juveniles, respectively, from other studies. For our final estimates we used the MMDM value as it is derived from our own data.

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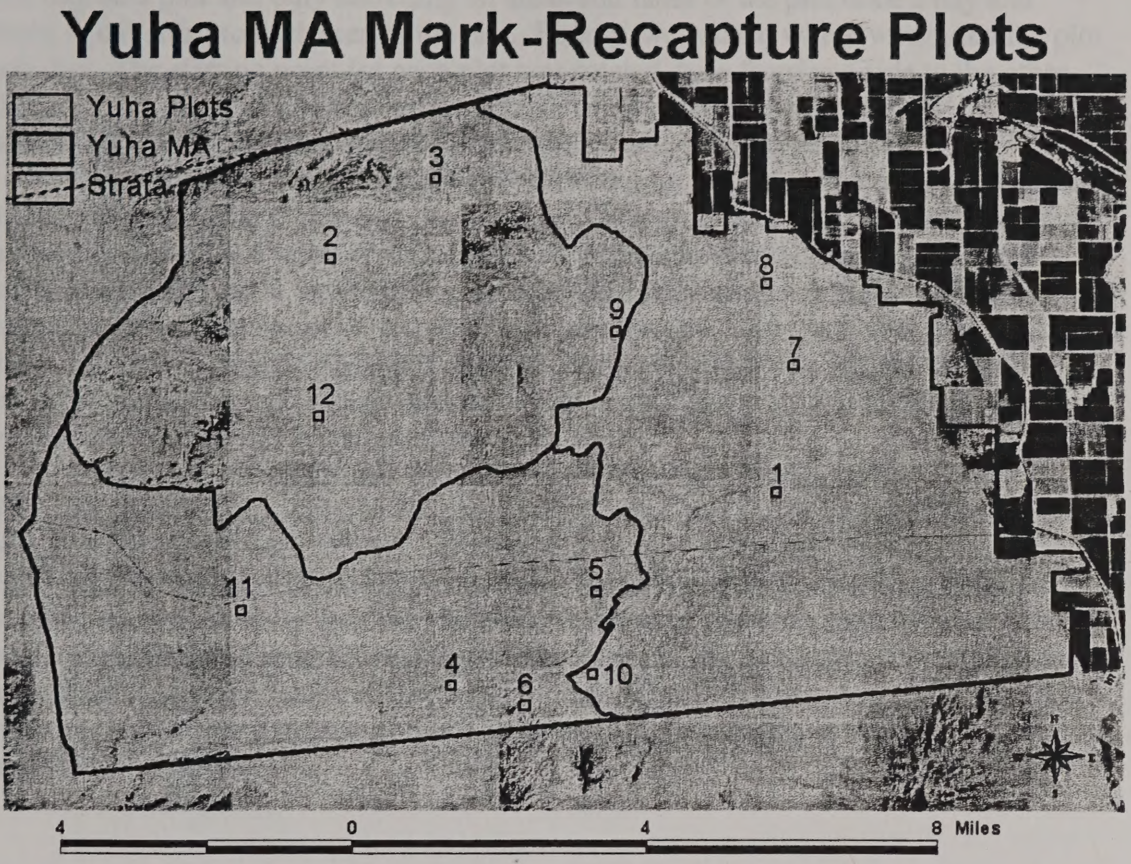


Figure. 2. Mark-recapture Plots (4 ha) for Flat-tailed Horned Lizards (*Phrynosoma mcallii*) in the Yuha Basin Management Area, Imperial County, CA, 2002. Rectangles to the East are Agricultural Fields.

The mean population estimate for each plot was divided by 7.14 hectares to yield the mean density. These mean densities were then used to calculate the grand mean for the entire Yuha population. The mean of the upper and lower population estimates were divided by 7.14 to give the upper and lower ends of the 95% confidence interval for the entire population's density. These densities were multiplied by the area sampled (24,113.4 hectares) yielding the population estimates for the Yuha population as shown below:

(7.48 lizards/7.14 ha) x 24,113.4 ha = 25,319 lizards = lower population estimate
1.33 lizards/ha x 24,113.4 ha = 32,071 lizards = mean population estimate
(11.47 lizards/7.14 ha) x 24,113.4 ha = 38,737 lizards = upper population estimate.

An important factor to population estimates is to have equal capture probability each day. There were several protocols we followed to do our best to maintain equal capture probability. We always used the same number of people each day on a plot. Adding another person could increase the probability of capturing lizards and invalidate our MARK estimates. Whenever possible we used the same people on a plot so as not to skew things by the fact that some technicians are better at finding lizards than others. We also made other efforts, such as searching for the generally the same amount of time each

each day on a plot and only searching all areas and lanes of the plot once a day and giving equal effort to each area of the plot. Finally, we rotated where we started the plot each day. The starting point for each plot was rotated daily from one side to the other and then from the center in either direction. This rotation ensured that every four days each portion of the plot was searched under the ideal temperature regime.

Data on habitat variables were also collected for each plot in a separate procedure (usually after flagging the plot on the first day). The procedure was modeled after impact surveys conducted last year (Wright, 2002). A technician walked the flag lines and recorded the substrate at the tip of his toe every fifth step of his/her right foot. This resulted in 500-700 point observations. Data on substrate, vegetation and vehicle impacts were collected. A vehicle track was recorded if the point was in a vehicle track of any kind of any age. Digital photos were also taken at each plot from the middle of the north and south sides, facing into the plot (see Appendices).

Statistics were performed with MicroSoft Excel, the VassarStats website (Lowry, 1998) and MARK. We took the six plots with the highest vehicle coverage and the six plots with the lowest vehicle track coverage and compared the means with a t-test for uncorrelated samples with unequal variances. We took the six plots with the highest sand coverage and the six plots with the lowest sand coverage and compared the means with a t-test for uncorrelated samples with unequal variances. The Spearman Rank Order Correlation Coefficient analyzed the trend in lizard sighting rates from 1979. Simple linear regression tested the relationship between lizard numbers and various environmental factors.

Mark-Recapture Plots in the Algodones Dunes (Imperial Sand Dunes Recreation Area and Algodones Dunes Wilderness Area)

Seven plots were randomly selected from the Algodones Dunes Wilderness and from the portion of the Open Area lying south of State Highway 78 and north of the large Interim Closure in the southern dunes (figure 3). The area lying within one half mile of the highway, railroad, Coachella Canal or Gecko Road was excluded to eliminate effects (OHV staging areas, highway mortalities, railroad mortalities, canal mortalities) associated with these features. Thus differences between the plots would be attributable either to natural habitat differences, rainfall or dispersed OHV use. The plots were surveyed in random order between June and October of 2002. By the end of the study period 6 plots had been completed in the Wilderness and 5 in the Open Area. A sixth plot was not done in the Open Area because lower temperatures had begun to depress lizard activity. Each plot was walked a minimum of two times with between 2 and 4 people using the same method as described above for the Yuha MA plots. The results were compared with a students t-test, assuming independent samples and unequal variances on the statistical program Vassarstats.

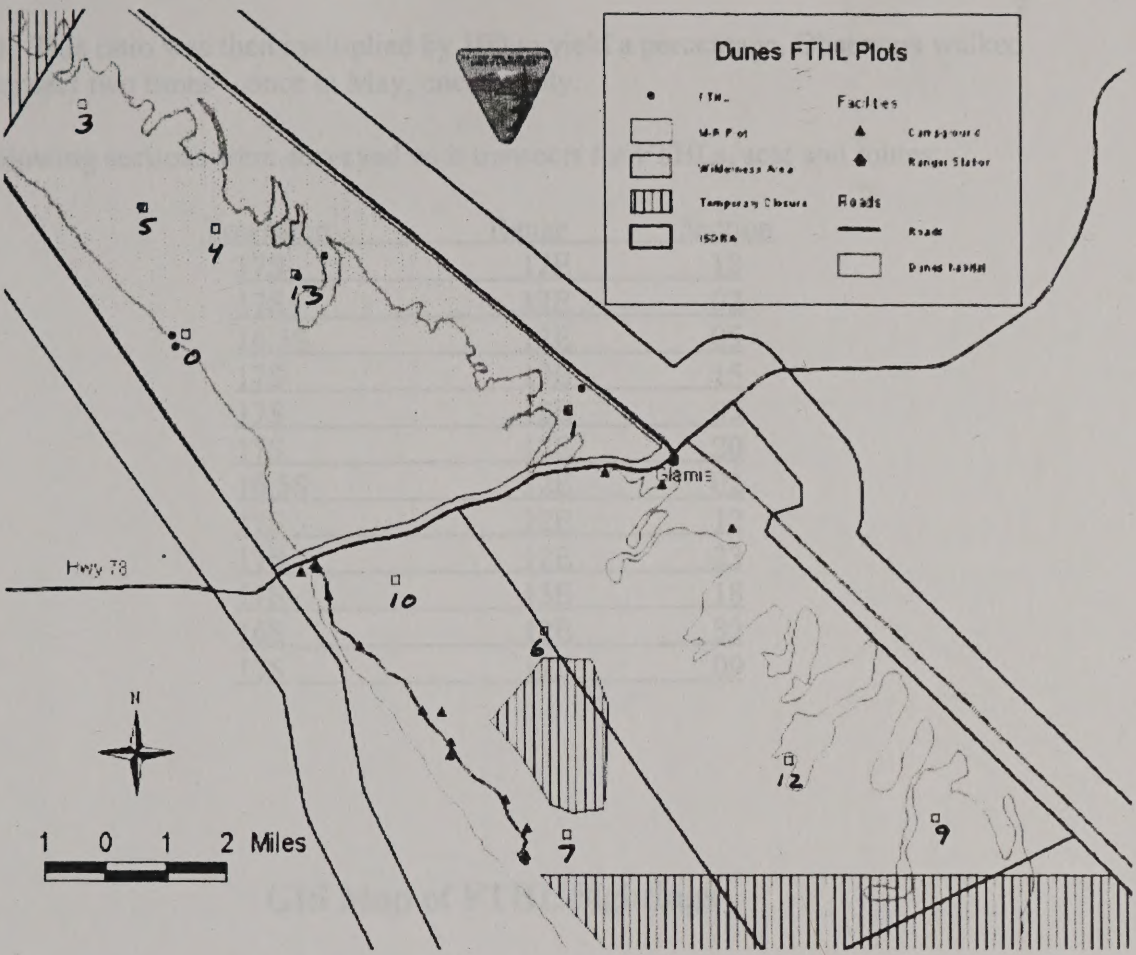


Figure 3. Location of Mark-Recapture Plots and Sightings of Flat-tailed Horned Lizard (*Phrynosoma mcallii dunsii*) in Algodones Dunes, Summer and Fall of 2002. Imperial County, CA.

FTHL Triangular Transect Surveys in the Yuha MA

BLM personnel walked twelve, 2.5 mile long by 50" wide transects in the eastern Yuha Desert. These transects were selected in a randomized systematic fashion in 1993. Prior to that time transects were selected from the same area in a variety of methods (Wright 2002). The observer walked along the transect recording all lizards, lizard scat and vehicle routes. Routes were defined as linear vehicle impacts at least 2 meters wide with a distinct depressed roadbed. The time elapsed from start to finish was recorded minus any break times. The total number of lizards seen was then divided by the time spent looking for lizards to yield the lizards per 10 hours statistic. Scat per hour was calculated by dividing the total number of ant scat > 5.5 mm wide by the number of hours spent looking for scat. The percentage of transects with scat or lizards was generated by dividing the number of transects with scat or lizards by the total number of transects

walked. This ratio was then multiplied by 100 to yield a percentage. Observers walked each transect two times – once in May, once in July.

The following sections were surveyed with transects for FTHLs, scat and routes:

Township	Range	Section
17S	12E	18
17S	12E	02
16.5S	12E	05
17S	12E	15
17S	12E	05
17S	12E	20
16.5S	12E	02
17S	12E	12
17S	12E	23
17S	13E	18
16S	12E	32
17S	12E	09

GIS Map of FTHL Sightings

The El Centro Office of the BLM has FTHL survey information dating back to 1978. All of the sightings recorded were put into a GIS context in ArcView (ESRI, Inc.). Recent sightings (2000-2002) have GPS coordinates taken from a GPS unit (accuracy +/- 10 m). Older sightings were recorded by pedometer and so have an estimated error or +/- .1 mile. A small percentage of the oldest sightings have only the township, range and section recorded so the sighting record was placed in approximately the center of the section.

Impact Surveys of the Yuha Basin MA

Impact surveys of the sections of the Yuha Basin MA were completed in 2002. These consisted of walking a triangular transect inside a section and recording substrate characteristics (especially vehicle impacts) at every 20th step. More details on this method can be found in Wright, 2002.

Results

Yuha Mark-Recapture Plots

Figure 4 shows the percentage of FTHLs that were recaptured in the last three days the plots were searched.

Recapture Rates of the Last Three Days

Plot #	Last Day – 2	Last Day – 1	Last Day
1	1 of 2 (50%)	0 of 2 (0%)	3 of 3 (100%)
4	8 of 15 (53%)	4 of 5 (80%)	7 of 12 (58%)
5	4 of 7 (57%)	3 of 5 (60%)	5 of 5 (100%)
6	4 of 5 (80%)	3 of 3 (100%)	6 of 7 (86%)
7	3 of 4 (75%)	6 of 8 (75%)	3 of 3 (100%)
8	2 of 3 (67%)	4 of 4 (100%)	3 of 4 (75%)
9	0 of 1 (0%)	1 of 1 (100%)	1 of 2 (50%)
10	1 of 2 (50%)	3 of 5 (60%)	2 of 2 (100%)

Figure. 4. Recapture Ratios for the Last Days on the Plots. Plots 2,3,11,12 had no Recaptures. Yuha Desert, Imperial County, CA. 2002.

MARK generated the probability of capture, p, as .3572. This means a lizard has a 35.72% chance each day of being captured on the plot if it has never been captured before. MARK also calculated the recapture probability, c, as .293. This is the probability each day of a particular lizard being recaptured. The data fits the M(b) model. The M(b) model accounts for a behavioral response to being captured. The FTHL has lower probability of being captured a second time; it apparently learns and makes some effort to avoid being recaptured. This model is also supported qualitatively by our field observations, that is FTHLs appeared to learn they were being pursued and were more adept at avoid repeat captures. Figure 5 shows the population estimate for the number of FTHLs using each plot during the sampling period.

Combined Adult and Juvenile Population Estimates

Plot Number	Estimate (# of FTHLs)	Lower bound (# of FTHLs)	Upper bound (# of FTHLs)	Density (FTHLs/ha)
1	7.067	6.264	7.870	0.99
2	1.007	0.978	1.037	0.14
3	0	0	0	0
4	31.805	25.194	38.416	4.45
5	12.624	10.132	15.116	1.77
6	14.765	11.076	18.454	2.07
7	17.109	13.131	21.086	2.40
8	10.757	8.130	13.385	1.51
9	5.087	4.028	6.146	0.71
10	12.485	9.843	15.128	1.75
11	1.002	0.993	1.0113	0.14
12	0	0	0	0
Sum	113.709	89.769	137.650	15.93
Mean	9.476	7.48	11.47	1.33

Figure. 5. Combined Adult and Juvenile Population Estimates for the 12 plots generated by MARK. All four values are the Sum of the Adult and Juvenile Values. Yuha Desert, Imperial County, CA. 2002.

Figure 6 has various habitat variables measured at each plot. The combined population estimate is given for reference. Figure 7 gives the values for r and r^2 of the correlation between the variables and the combined population estimate.

Habitat Variables of the Plots

Plot #	Vehicle Track (%)	Sand (%)	Perennial Plant Cover (%)	Number of Routes or graded roads	Average Scat/day	Combined Population Estimate # of FTHLs
1	1.7	81.9	2.3	1	.286	7.067
2	9.7	23.4	0	2	.2	1.007
3	25.0	43.1	3.6	5	0	0
4	6.8	76.1	2.9	1	3.2	31.805
5	10.9	52.3	4.7	0	.4	12.624
6	0.03	73.1	4.6	0	.333	14.765
7	4.2	50.8	8.8	0	2.286	17.109
8	6.0	44	2.6	0	1	10.757
9	0.9	26.9	0.4	5	0	5.087
10	19.6	23	1.4	2	0	12.485
11	15.0	2.2	7.6	0	0	1.002
12	9.0	30.2	0	2	.25	0
Mean	9.1	43.8	3.2	1.5	0.663	9.476

Figure. 6. Habitat Variables and Population Estimates for Flat-tailed Horned Lizards (*Phrynosoma mcallii*) on Twelve 4 ha Plots in the Yuha Desert, Imperial County, CA. 2002.

Habitat-Population Correlations

Habitat Variable	r	r^2	Two-tailed p
Track coverage	-.325	.105	0.303
Sand coverage	.616	.38	0.032
Perennial coverage	.254	0.065	0.425
Scat	.695	.483	0.012
Routes and Roads	-.422	.178	0.172

Figure. 7. Correlation and Regression of Some Habitat Variables with the Combined Population Estimates of Flat-tailed Horned Lizards on Twelve 4 ha Plots. Yuha Desert, Imperial County, CA. 2002.

Perennial plant cover was very poorly correlated with lizard numbers (r=.27, r^2=.073, two-tailed p=.40). Sand and track coverage were negatively correlated with each other (r= -.48); the regression was near the 0.1 significance level (r^2=.232, p=.112).

The mean of the low track coverage plots was 16.5 lizards/plot; the mean of the high track coverage plots was 4.7 lizards/plot. A t-test indicates the difference is significant at p=.046. Plots with greater than 44% sand coverage (n = 6) had 5.6 times as many lizards (mean = 17.5 per plot) as those with less than 44% track coverage (mean = 3.1 per plot, n = 6, p = .006). Plots with a vehicle route or road averaged 9.3 lizards per plot while those without a route or road averaged 12.4 lizards per plot, however this difference had very low statistical significance (p = .63).

Population size was not significantly correlated with track coverage (figures 7 and 8). Population size was significantly correlated with sand coverage on the plots (r=.621, r^2=.386, two-tailed p=.03 (figures 7 and 9).

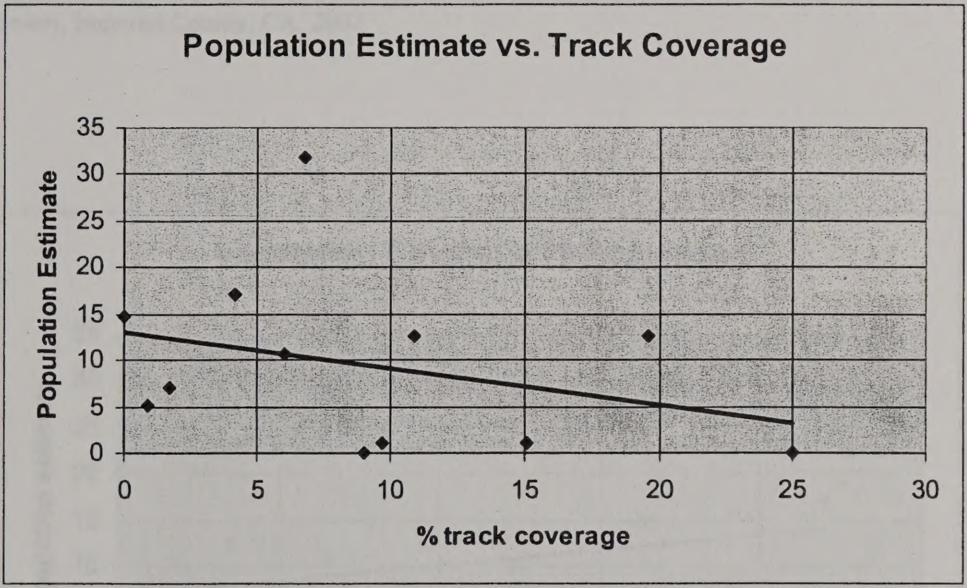


Figure. 8. Regression of Vehicle Track Coverage and Population Size of Flat-tailed Horned Lizards. Yuha Desert, Imperial County, CA. 2002.

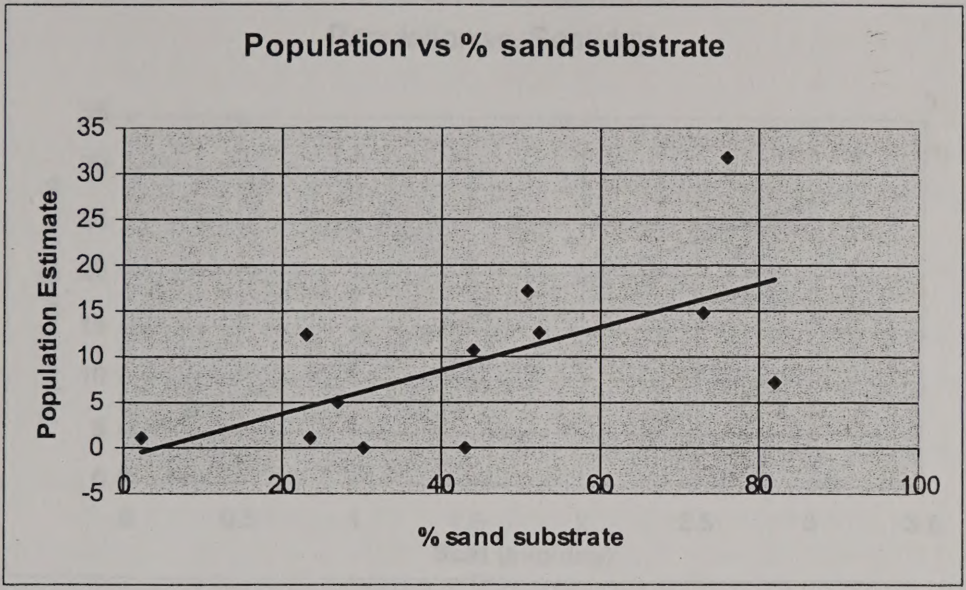


Figure 9. Regression of Sand Coverage on the Plot and Flat-tailed Horned Lizard Population Size . Yuha Desert, Imperial County, CA. 2002.

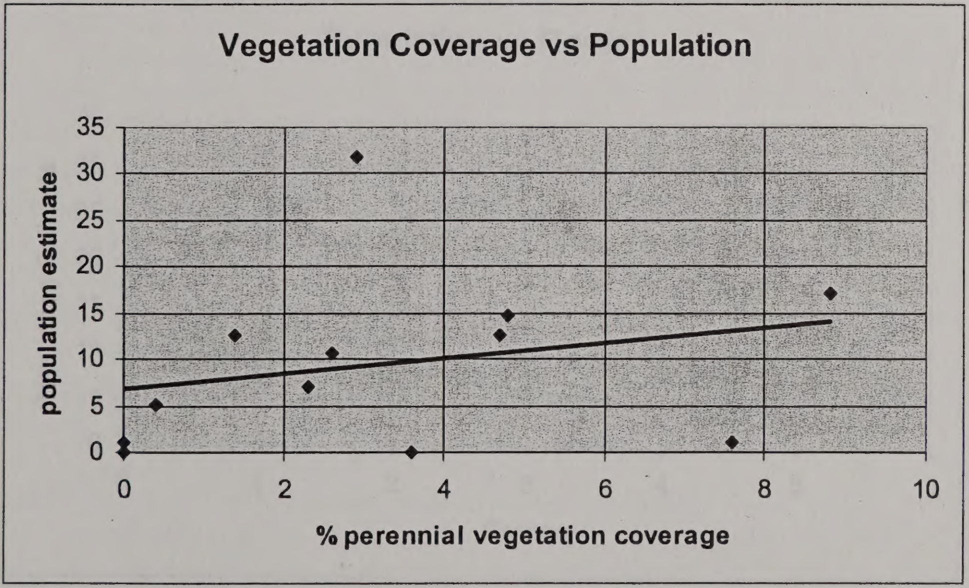


Figure 10. Regression of Perennial Vegetation Cover on the Plot and Flat-tailed Horned Lizard Population Size. Yuha Desert, Imperial County, CA. 2002.

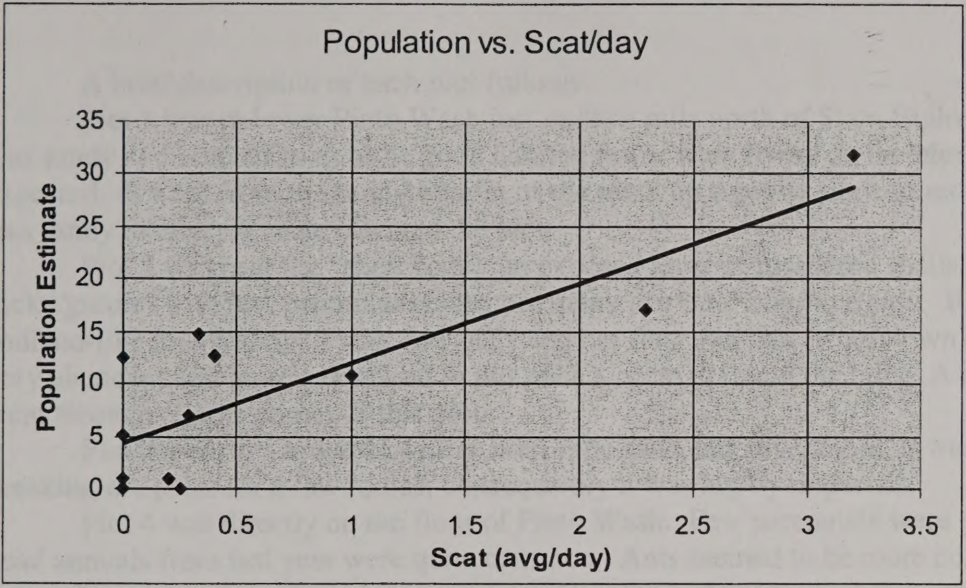


Figure. 11. Regression of Average Scat per Day on the Plot and Flat-tailed Horned Lizard Population Size. Yuha Desert, Imperial County, CA. 2002.

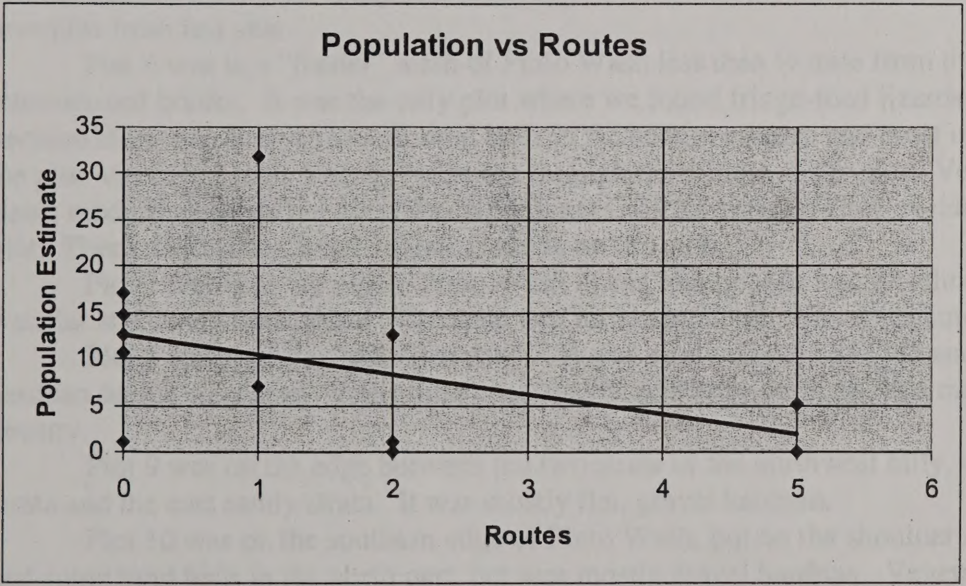


Figure 12. Regression of Routes or Roads on the Plot and Flat-tailed Horned Lizard Population Size. Yuha Desert, Imperial County, CA. 2002.

A brief description of each plot follows:

Plot 1 was in lower Pinto Wash just under a mile north of State Highway 98. It was sandy and seemed to us to be good habitat; fewer were found on the plot than we expected. It went from the sandy bottom of the wash up a gentle slope to more upland, less sandy habitat. A route bisected the plot.

Plot 2 was near the "shell beds", an exposed layer of fossilized shells. It was rocky ground with few perennial plants, but many dry *Chorizanthe rigida.* It had badland-like topography; it was very hilly and not flat. Aeolian (windblown) sand wasn't very abundant and mostly confined to the wash system draining the hills. A route also went through a large corner of this plot.

Plot 3 was on a low rocky ridge with little sand and vegetation. It was right at the breaking-off point for a few routes; consequently it was highly impacted.

Plot 4 was directly on the floor of Pinto Wash. Few perennials were present, but dead annuals from last year were quite common. Ants seemed to be more common here. It was flat and very sandy with some exposed hardpan. A route went through one corner; this route is regularly "dragged" by the Border Patrol with a row of tires to smooth out the surface. This allows them to see new tracks of illegal immigrants.

Plot 5 was a quarter of a mile from Pinto Wash above it on the shoulder. It had gentle slopes and most of it was sandy, though a lot of was somewhat coarser sand. Creosote was fairly abundant. No routes went through the plot, but there was some vehicle tracks on the plot. Only one adult lizard was found on this plot; all the rest were juveniles from last year.

Plot 6 was in a "feeder" wash of Pinto Wash less than ½ mile from the international border. It was the only plot where we found fringe-toed lizards, probably because there was deep and large sand beds in the southwest area and most of the rest of the plot was sandy too. A rocky ridge ran through the middle of the plot. Vegetation was about medium density, but there was significant Galletta grass *(Hilaria rigida)* on this plot. There were virtually no vehicle impacts on the plot.

Plot 7 was near the where Pinto Wash opens and spreads into its alluvial fan. It was flat and sandy throughout. Creosote was fairly abundant. No routes entered the plot.

Plot 8 was near the "pole line road." It was sandy on the east side and gravelly hardpan on the west side. Vegetation consisted of primarily creosote, at a medium density.

Plot 9 was on the edge between the two strata of the northwest hilly, badland strata and the east sandy strata. It was mostly flat, gravel hardpan.

Plot 10 was on the southern edge of Pinto Wash, but on the shoulder above it. It had some sand beds in the north part, but was mostly gravel hardpan. Vegetation was small numbers of creosote and galletta grass.

Plot 11 was in the far western Yuha MA. It had quite a bit of Creosote and *Ambrosia dumosa.* Fine gravel beds and gravel hardpan were the dominant substrate. It was less than ¼ mile from highway 98. No routes went through the plot. There was virtually no aeolian sand on the plot. A desert horned lizard (*Phrynosoma platyrhinos*) was found on the plot, along with the single FTHL.

Plot 12 was badland-like, cut by washes, with very little vegetation. Sand was usually coarse. A number of routes go through and are near the plot.

The term "gravel hardpan" as used here refers to a common substrate of crusty soil with a scattering of individual pieces of gravel on the surface. The density and size of the gravel varies. The other common substrate is aeolian sand deposits or "beds," which can be of varying depths and the sand can be fine or coarse.

Algodones Dunes Mark/Recapture Plots

The number of flat-tails seen in the wilderness area was greater (p > .07) than the number seen in the open area (figure 13).

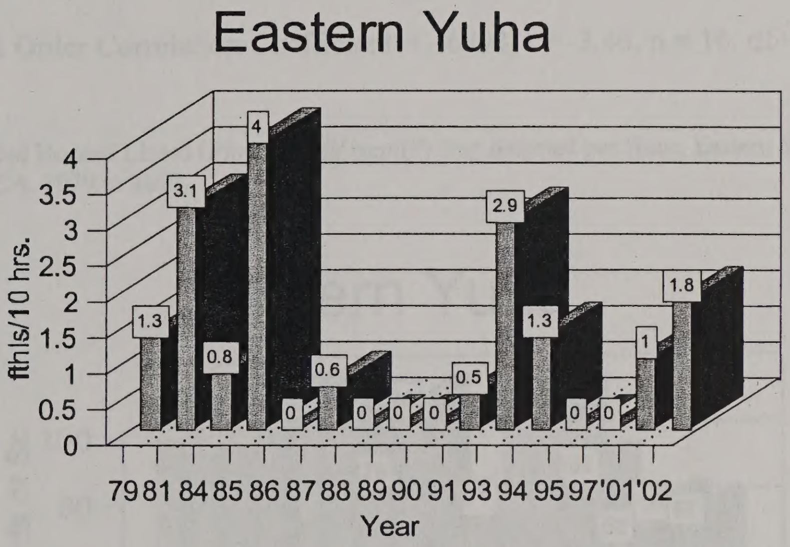
	# of plots	#FTHLs on plots	#FTHLs off plot	mean FTHLs/plot
Wilderness	6	3	4	0.5
Open Area	5	0	0	0.0

p-value for 2 tailed t-test for independent samples: 0.07. t = -2.02, df = 9.

Figure 13. Results of T-test Comparing the Number of Flat-tailed Horned Lizards (*Phrynosoma mcallii*) Found in the Wilderness and Open Areas of the Algodones Dunes. Imperial County, CA. Summer 2002.

Yuha Triangular FTHL Transects

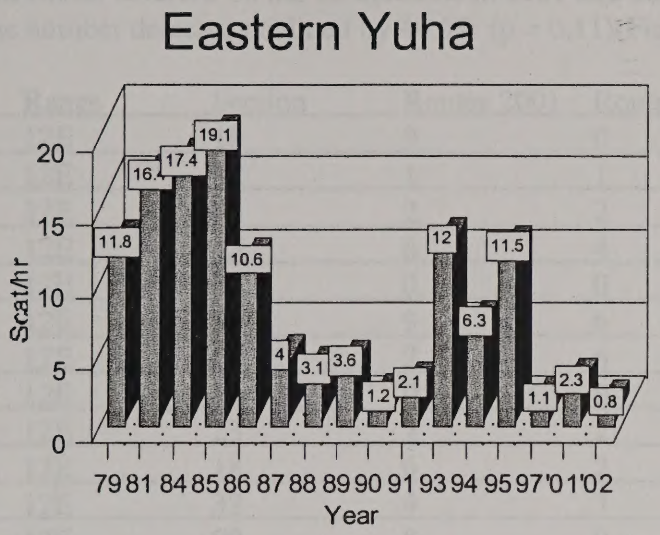
The number of flat-tails seen per 10 hour period from 1979 to 2002 did not have a significant trend (figure 13). The spearman-rank correlation statistic did not detect a significant (p = 0.51) trend in these data. The amount of scat detected per observer-hour declined significantly (p = .004) from 1979 to 2002 (figure 14) while the percentage of transects with flat-tails or their scat declined (p = .07) at a level approaching the commonly used .05 level (figure 15).



Spearman Rank Order Correlation Coefficient Statistic to detect trend.

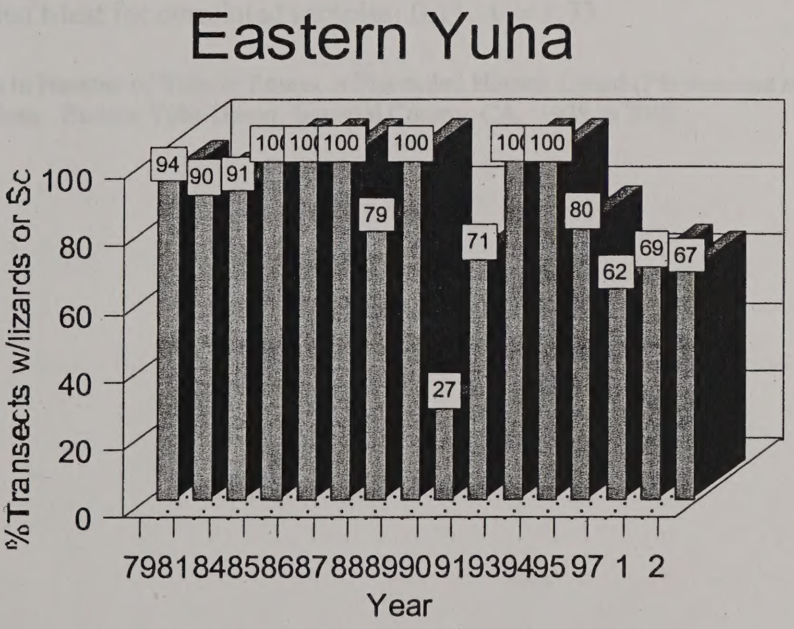
rs	n	t	df	p (2-tailed)
-0.18	16	-.68	14	0.51

Figure 14. Flat-tailed Horned Lizard Detection Rate and Test for Trend (lizards seen per 10 hours). 1979 to 2002. Eastern Yuha Desert. Imperial County, CA.



Spearman Rank Order Correlation Coefficient = -.6794, t = -3.46, n = 16, df = 14, p = .004, 2-tailed.

Figure 15. Flat-tailed Horned Lizard (*Phrynosoma mcallii*) Scat detected per Hour. Eastern Yuha Desert. Imperial County, CA. 1979 to 2002.



Spearman Rank Order Correlation Coefficient = -.4651, t = -1.97, n = 16, df = 14, p = .07.

Figure 16. Percentage of Transects with Flat-tailed Horned Lizards or Their Scat. Eastern Yuha Desert. Imperial County, CA. 1979 to 2002.

The number of routes detected on the 12 transects in 2001 and 2002 is shown in the figure below. The number detected declined by 44.5% (p = 0.11)(Figure 17).

Township	Range	Section	Routes 2001	Routes 2002	+/-
17S	12E	18	9	0	-9
17S	12E	02	1	1	0
16.5S	12E	05	2	2	0
17S	12E	15	6	4	-2
17S	12E	05	0	0	0
17S	12E	20	9	6	-3
16.5S	12E	02	2	6	+4
17S	12E	12	0	0	0
17S	12E	23	7	2	-5
17S	13E	18	6	2	-4
16S	12E	32	4	7	+3
17S	12E	09	8	0	-8
Total	-	-	54	30	-24

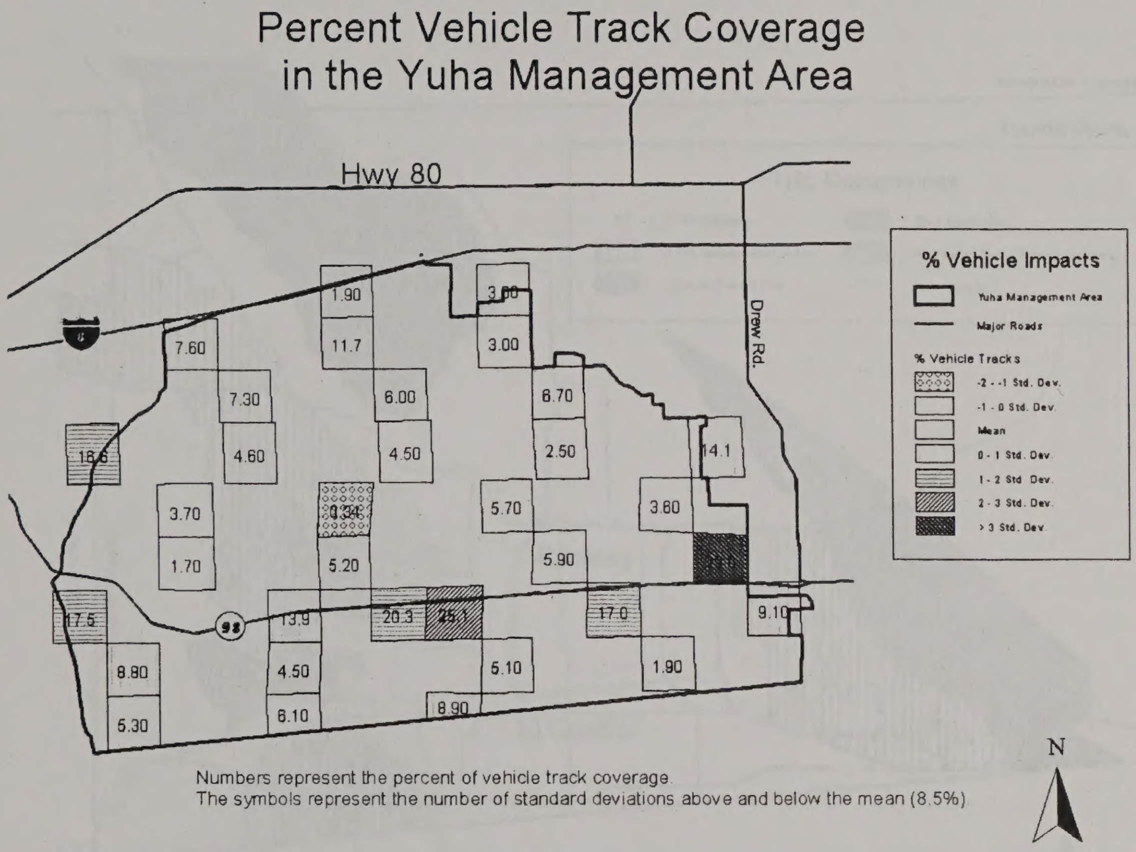
Number of routes detected on 12 lizard transects in 2001: 54. 4.5 routes/transect.
Number of routes detected on 12 lizard transects in 2002: 30. 2.5 routes/transect.
% change: -44.5

p-value of 2 tailed t-test for correlated samples: 0.11. t = 1.73.

Figure 17. Change in Number of Vehicle Routes in Flat-tailed Horned Lizard (*Phrynosoma mcallii*) Habitat on 12 Sections. Eastern Yuha Desert, Imperial County, CA. 1979 to 2002.

Impact Surveys of the Yuha MA

The percentage of the surface of the Yuha Management Area with vehicle tracks on it was 8.5% with a 95% confidence interval of 6.1 to 11.1% (figure 18).



Numbers represent the percent of vehicle track coverage.
The symbols represent the number of standard deviations above and below the mean (8.5%)

Figure 18. Percentage of Surface Covered with Vehicle Tracks, Yuha Desert. 2001-2002. Imperial County, CA.

Map of FTHL Sightings

Historic sightings have occurred from the Borrego Badlands to Pilot Knob Mesa (figure 19).

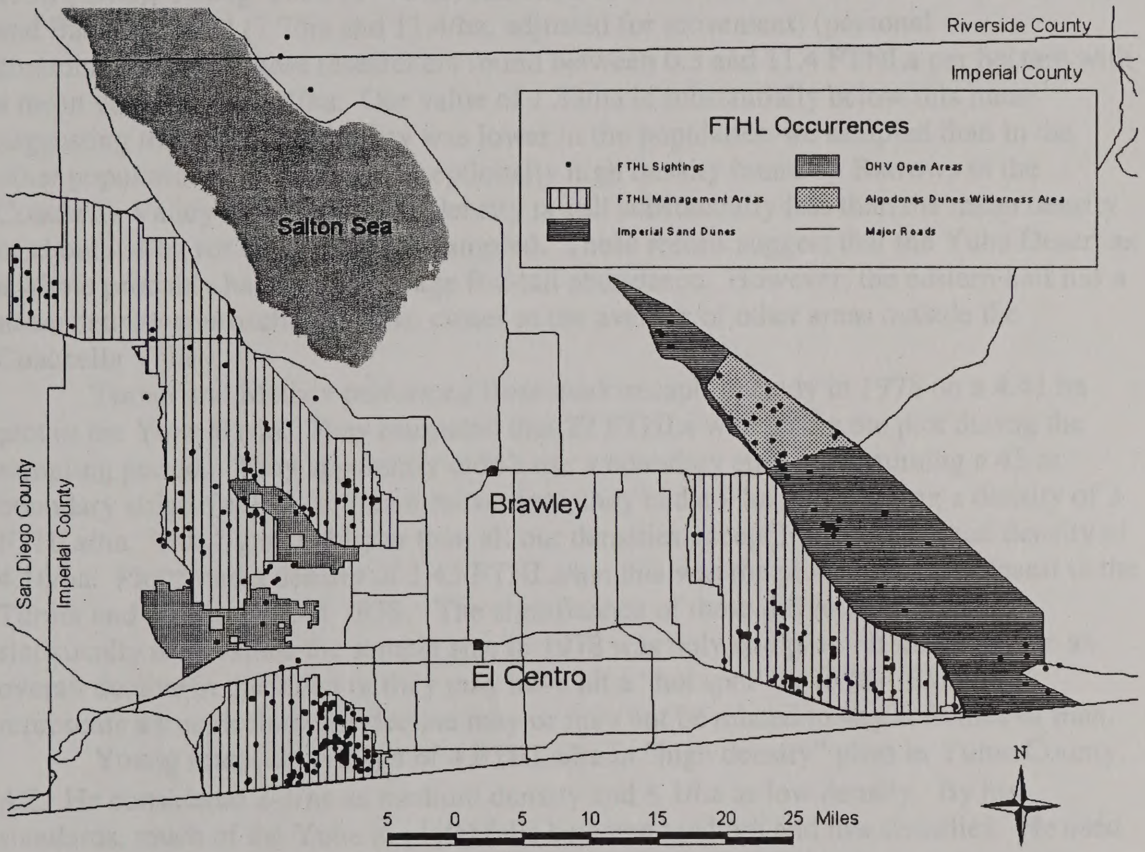


Figure 19. Historic (1978-Present) Flat-tailed Horned Lizard (*Phrynosoma mcallii*) Sightings, Imperial and San Diego Counties, CA.

Discussion

Yuha Mark-Recapture Plots

Several other researchers have calculated density estimates for the FTHL: Turner and Medica, 1982 (6 – 8/ha, later adjusted for movement to 3.8/ha); Muth and Fisher, 1992 (1.4/ha); Rorabaugh, 1994 (.1 to .6/ha); Hodges, 1995 (.6/ha); Beauchamp et. al, 1998 (.3/ha); Young, 2000 (1 – 4/ha) (all cited in U.S. Fish and Wildlife Service, 2002); and Barrows, 2002 (7.7/ha and 11.4/ha, adjusted for movement) (personal communication). These researchers found between 0.3 and 11.4 FTHLs per hectare with a mean value of about 4/ha. Our value of 1.33/ha is substantially below this mean suggesting that the lizard density was lower in the population we sampled than in the other populations. Even if the exceptionally high density found by Barrows in the Coachella Valley is excluded, our density is still substantially less than the mean density of about 2.4/ha for the other areas sampled. These results suggest that the Yuha Desert as a whole probably has below average flat-tail abundance. However, the eastern half has a mean density approaching 1.9/ha, closer to the average of other areas outside the Coachella Valley.

Turner and Medica performed their mark-recapture study in 1978 on a 4.41 ha plot in the Yuha Basin. They estimated that 27 FTHLs were using the plot during the sampling period. They apparently didn't use a boundary strip but assuming a 45 m boundary strip to adjust for lizard movement, they had a 9 ha plot yielding a density of 3 FTHLs/ha. This figure is higher than all our densities except Plot 4 which had density of 4.16/ha. Plot 5 had a density of 1.43 FTHLs/ha; this was the plot physically closest to the Turner and Medica plot of 1978. The significance of these differences can't be statistically tested since the sample size in 1978 was only one plot. It may indicate an overall decline in the Yuha or they may have hit a "hot spot" in 1978. Even if it represents a true decline, the decline may or may not be related to any activities of man.

Young found an average of 4 FTHLs/ha in "high density" plots in Yuma County, AZ. He considered 2-3/ha as medium density and ≤ 1/ha as low density. By his standards, much of the Yuha (6 plots) falls between medium and low densities. He used a different method than mark-recapture, however. His densities were a snapshot of density measured during 1 or 2 days, while ours were densities over 5-9 days (including weekends), so our data may be more accurate.

Muth and Fisher, Hodges, Rorabaugh and Beauchamp all found densities on the low side (0.3 to 1.4 FTHLs/ha), similar to ours. By contrast Barrows found much higher densities at the Coachella Valley Preserve (7.7/ha and 11.4/ha, assuming the same 45 meter boundary strip we used). However, these studies may have focused on areas naturally high in FTHLs to facilitate study with adequate sample sizes; by contrast we sampled all habitats throughout the Yuha, including areas unsuitable for focused studies (due their very low densities). So some of the density differences observed may be due to this study selection bias.

FTHL densities can apparently fluctuate widely, judging from the two decades of BLM data (Wright 2002, Young 2000). It's important to consider our density results in light of the fact that 2002 may have been part of an upswing in FTHL numbers. In the

summer and fall of 2001, the Yuha experienced above average reproduction because of the wet previous winter and spring. In July during the pilot mark-recapture study, 60% of the FTHLs captured were hatchlings (under 50 mm SVL) and hatching had just begun. Juveniles presumably kept hatching out until November or later. Of the FTHLs captured in 2002, almost 70% were 70 mm or less. Anything under 70 mm almost certainly hatched last year (2001) or in 2002 (there was no clear gap in size indicating this 2001's and 2002's juveniles) because all the adults we captured in 2001 were already near or above 70mm. This species may have high levels of predation (Young, 2000) and therefore high percentages of juveniles each year, but this year's juvenile percentage was probably higher than the average. The high numbers of juvenile FTHLs may skew the densities upward this year. Reproduction this fall won't be nearly as high due the low rainfall last winter (2001-2002). Given such large changes in density due to rainfall patterns, it's difficult to judge the health of a population from a single year of data. Furthermore, no Yuha population estimates from previous years are available, so we have no way of knowing if the estimate of 32,071 is relatively high or low.

Vehicle Impacts

Vehicle impacts are a major concern to FTHL conservation. While our results do show some depressive effect from vehicles ($r^2 = .105$ and .178), p values are relatively high (.303 for track coverage and .172 for routes) (figure 7), meaning a strong possibility exists that such an "effect" would be detected in randomly generated numbers. It appears that sand coverage has a greater impact on flat-tail populations than vehicle impacts ($r^2 = .38$, $p = .03$). As an example of these statistics reflected on the ground, a relatively busy route goes right through a corner of plot 4 and is dragged regularly by the Border Patrol with tires. 6.8% of the plot is covered with vehicle tracks. Despite these impacts, plot 4 had almost twice as many FTHLs as the next most abundant plot. This was plot 6, which had virtually no vehicle impacts. The poor correlation of population size with vehicle impacts and the significant positive correlation with sand suggest that the latter factor is more predictive of lizard numbers.

Nonetheless, at some level vehicle impacts should start to depress FTHL populations due to mortality, devegetation and soil compaction. Our results suggest that this depression may start to occur above 9% track coverage because significantly fewer FTHLs were found on such plots. However, track coverage itself is not a perfect indicator of vehicle impacts. Tracks disappear more quickly in sand and persist longer on other surfaces. This can be seen in the weak negative correlation between tracks and sand ($r = -.48$, $r^2 = .232$, $p = .112$). Presumably, tracks are more easily eradicated by wind on sandy surfaces than they are on gravel or hardpan surfaces. For that reason, vehicle tracks are also a reflection of the substrate characteristics as well as the level of vehicle impacts. This difference may account for some of the lack of correlation between tracks and lizard numbers. These more highly impacted plots also had much less sand (mean = 29% vs. 59% for low impact plots). This sand coverage difference probably accounted for some of the observed difference in lizard numbers between low and high track plots. This comparison also suffers from the reduced inferential power of *a posteriori* (after the fact) analyses.

Presumably, the main detriment of vehicle traffic would be mortality from actually being run over and habitat degradation. This mortality would be a function of vehicle impacts per unit time, which our methods didn't measure. In other words, a lot of tracks doesn't necessarily mean frequent or recent vehicle traffic, since tracks may be fairly old and represent only intermittent traffic. On the other hand, a route with lots of traffic may cover only a small area of the plot but cause more mortality than dispersed traffic if the route is heavily driven. While the number of routes going through the plots was counted, they may get different amounts of traffic. Future work may want to incorporate vehicle impacts with a time dimension.

Highway 98 traverses the Yuha MA and has fairly high traffic levels. Its impact on density was apparently quite high on one transect in the Yuha in 2001; 87% fewer FTHLs were found within 0.45 miles of the Highway (Grant, et al 2001). It may have greater effect than the dispersed driving of the Border Patrol due to the much greater frequency of vehicles on the Highway.

An additional confounding factor in our regression analyses of vehicle impacts is that we didn't control for habitat characteristics. Substrate, topography and vegetation all varied widely on our plots preventing the isolation of just the impact of vehicles. Additionally, rainfall undoubtedly varied between plots and this variable was not even measured. In an attempt to reduce the variation created by sand coverage, *a posteriori* we eliminated the 5 least sandy plots (those with less than 40% sand coverage – the level at which lizard numbers begin to climb) and ran the regression analyses again. In these two cases, the correlations while more negative are still not significant ($r = -.47$, $r^2 = .22$, slope = -.553, $p = .29$ for track coverage and $r = -.51$, $r^2 = .26$, $p = .24$ for number of routes or roads). These results suggest at most a modest depressive effect on lizard numbers from vehicle impacts. A possibility exists that no depressive effect exists at current impact levels and that the negative correlation is simple a product of random variation in the sample. A study which controls for habitat and rainfall variables is need to test this hypothesis further, ideally with randomly chosen plots within two strata that have no substantial differences in habitat quality, i.e. equal sand coverage, same topography and vegetative characteristics, rainfall etc. Such a study should also assess the impact of track coverages greater than 25%, such as commonly occur in Open Areas. Conversely, one could argue that the correlation we tested for (that does not control for other variables) is valuable because it includes all factors impacting the lizard and hence evaluates the net effect of vehicles on FTHLs in light of all ecological factors.

Currently, the mean track coverage in the entire MA is 9.2%, as measured on mark-recapture plots or 8.5% as measured along triangular transects. The mean track coverage in the eastern Yuha, where most of the FTHLs are, was measured at 10.5% in 2001 (Wright 2002). So it appears that current vehicle impact levels in the Yuha MA are at a level that may begin to reduce lizard numbers. Therefore, it would be prudent to reduce vehicle impacts below this 9% level. Vehicle impacts should be closely monitored every 2 to 3 years to ensure that they are declining.

Rainfall

The poor correlation between FTHL population sizes and habitat variables reflects our marginal understanding of exactly what makes some areas densely populated and

others sparsely populated. One variable we don't know is the amount of rainfall on each plot for the past year or two. Rainfall can be very spotty in the desert. One of the authors (GW) placed rain gauges in several different areas of the Imperial Valley in the early 1990's and observed large differences in the amount of rainfall (Wright, 1993.). Some of the variation in population size on our plots may be due to unknown precipitation differences.

The Yuha MA appears to rather densely populated in its eastern half and only very sparsely populated in its western half, presumably due to the lower sand coverage in the west. The eastern half, especially the Pinto Wash area appears to be the "mother lode" of flat-tails and should be carefully conserved. Given the large size of the population estimate, the lack of habitat fragmentation and contiguity with the Mexican population, the species does not appear to be in any immediate danger in the Yuha Desert. Plots should be repeated every 2 or 3 years to monitor the population level and to ensure the population persists through time.

Scat Counts

The significant correlation between scat and lizard numbers suggests that scat counts that have historically been done may be of value as a rough indicator of FTHL abundance. Our results are contrary to those of Beauchamp et. al (1998) who did not find a significant correlation. It may be that in some cases environmental factors such as wind may reduce or eliminate scat to such an extent that scat counts are essentially useless as an indicator of abundance. Such factors may differ between the location of Beuchamp's study site and ours.

Vegetation

The lack of correlation with perennial vegetation is interesting because other researchers have found a strong correlation in Imperial County (Turner and Medica, 1982). However, Beauchamp, et al. (1998) found a negative correlation between perennial density and FTHL density at Ocotillo Wells State Vehicle Recreation Area (SVRA). Our data showed virtually no relationship between lizard numbers and perennial vegetation, an odd finding given that vegetation provides both thermal and predator cover for FTHLs and is the primary food source for the FTHLs main prey of ants. It may be that the recent rainfall and sand are the overriding influences on lizard numbers rather than vegetation.

Loss of Marks

A concern in mark-recapture is subjects losing their marks. The chance of this happening is very low for FTHLs and when it does, usually a researcher can see skin starting to come off and mark some "new" skin to know which lizard is shedding. We also re-examined FTHLs at plot 4 two weeks after our work there and found a similar percentage of FTHLs unmarked as they did on their last day there. Dan Mulcahy at Utah State University tracked FTHLs with transmitters at Ocotillo Wells SVRA for only 1 week out of a month. When they would return after the 3 weeks away to monitor for a

week, few FTHLs would have shed and thus lost their transmitter. It seems that in adults anyway, shedding is unlikely to take place in the course of a 1-1.5 week study. In late October, we found two FTHLs on plot 4 that still had visible marks.

Algodones Dunes Plots

In the Algodones Dunes, only 3 FTHLs were found on plots, with 4 being found off plots (while walking to and from plots). However, all of these were found in the Wilderness rather than the Open Area (Figure 3). Several possible explanations may account for this difference: 1) the habitat in the Wilderness is naturally better 2) more rain has fallen in the last couple of years in the Wilderness (unknown) or 3) OHV impacts have reduced the number of FTHLs in the Open Area. The habitat in the Wilderness is composed of shorter, thinner and less active dunes than in the Open Area, a feature that may make the Wilderness Area more suitable for FTHLs. No rainfall data are available comparing the Wilderness with the Open Area, so it is impossible to address this explanation. OHV impacts are extensive in the Open Area and virtually absent in the Wilderness. This difference in OHV impacts may account for some of the difference in the number of FTHLs detected.

Many more plots, probably on the order of one hundred or more, would be necessary to reliably determine if more FTHLs occur in the Wilderness than the Open Area. That said, the t-test comparing the 2 areas (figure 11) showed that the Wilderness likely has more FTHLs (p = .07). Due to the very low density of flat-tails in the Dunes, monitoring this population is not practical. Resources would be better directed toward other goals, such as invertebrate monitoring, for example for the three endemic beetle species that occur at the Dunes. As an aside, FTHLs were detected in the Open Area during the summer of 2002 during other surveys, so the species still occurs in the Open Area.

Assuming that the density of 0.01 FTHLs detected per acre in the Dunes is accurate, the entire Algodones Dunes Recreation Area would be expected to contain about 1,750 FTHLs (.01 flat/acre x 175,000 acres). Given that the Dunes are now separated from East Mesa by the Coachella Canal, this population may not be viable in the long-term, particularly in light of heavy OHV impacts in some portions of the RA. Historically, the East Mesa area, where dense flat-tail populations occur probably recharged the RA but now with the Canal in the way such recharge events are probably very rare if they occur at all.

Yuha FTHL Transects and Impact Surveys

The FTHL transect data for the eastern Yuha present a contradictory picture as the rate of lizard detection shows no significant trend, whereas the rate of scat detection and the percentage of transects with FTHLs or scat have declined significantly (p = .004) or nearly significantly (p = .07). However, given the fact that none of these indicators is particularly sensitive to changes in the population size (Wright 2002), it would be unsafe to make strong conclusions about trends in the population size since 1979.

Vehicle impacts in the Yuha Desert appear to be strongly elevated near State Highway 98 (Figure 18). Presumably such impacts have reduced the abundance of *FTHLs* along a strip on either side of the Highway as a result of direct vehicle mortality and degradation. An earlier study (Grant et. al. 2001) showed that within 0.45 miles of this highway lizard abundance was reduced by 87%. This reduction could be as much a result of off-road traffic associated with Highway access as lizard mortality on the Highway itself.

Flat-tail Sightings

The distribution of sightings (figure 19) gives some indication as to the lizard's range but should not be used to infer relative abundance. This is because the number of sightings is as much a function of survey effort as abundance. For example, the relatively low number of sightings in the northern portion of East Mesa (the area east of Brawley) may be primarily a result of the historically low survey effort in this area. Some areas have reliable reports of lizard sightings but the exact location was not available at the time of this compilation. For example, Rorabaugh (pers. comm., 1998) reports FTHLs near the small town of Ocotillo west of the Yuha Management Area. How far west the species extends in this area is uncertain. Sightings show that the lizard occurs on the west side of the Valley from Anza-Borrego State Park south through West Mesa and the Yuha Desert. The developed part of the Valley contains no FTHLs but presumably much of this area once had FTHLs when it was open desert. Lizard sightings begin again in East Mesa and extend eastward across the Algodones Dunes onto Pilot Knob Mesa. It is uncertain how far east toward Pilot Knob the species goes. Similarly, whether the species occurs north of East Mesa along the east side of the Salton Sea is uncertain, although it does occur northeast of the Sea in the vicinity of the Dos Palmas Preserve. Additional surveys are needed in these areas to determine distribution.

Conclusions

We conclude that the mark-recapture technique is an effective means of determining FTHL abundance over a wide area, that lizard numbers may not be strongly correlated with vehicle impact levels in the Yuha (natural factors such as sand coverage apparently having a greater impact) and that scat counts may be of value in some areas as rough indicators of relative abundance. The Algodones Dunes are very low density FTHL habitat and may have a higher density of FTHLs in the Wilderness. This higher density may be a result of OHV impacts, habitat differences, rainfall differences or some combination of these effects. Long-term monitoring data of the lizard in the Eastern Yuha desert are contradictory and inconclusive, however the entire Yuha Desert currently supports a viable population of FTHLs with a moderate (8.5%) level of vehicle impacts.

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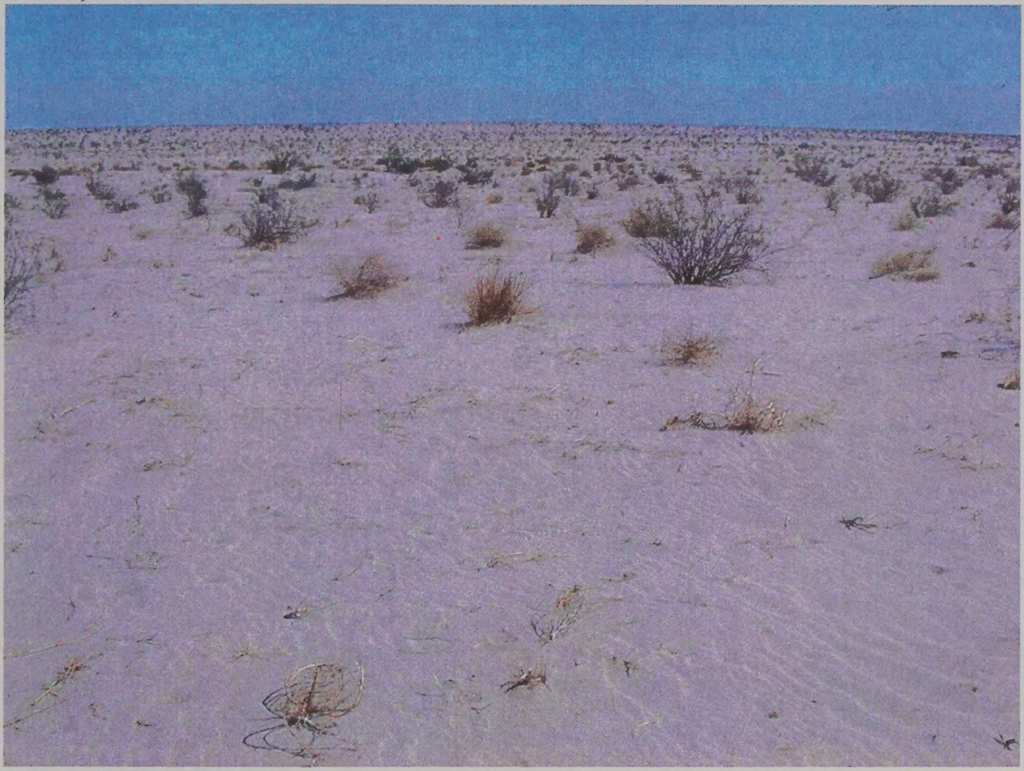
Appendix A

Yuha Basin Plot Photos

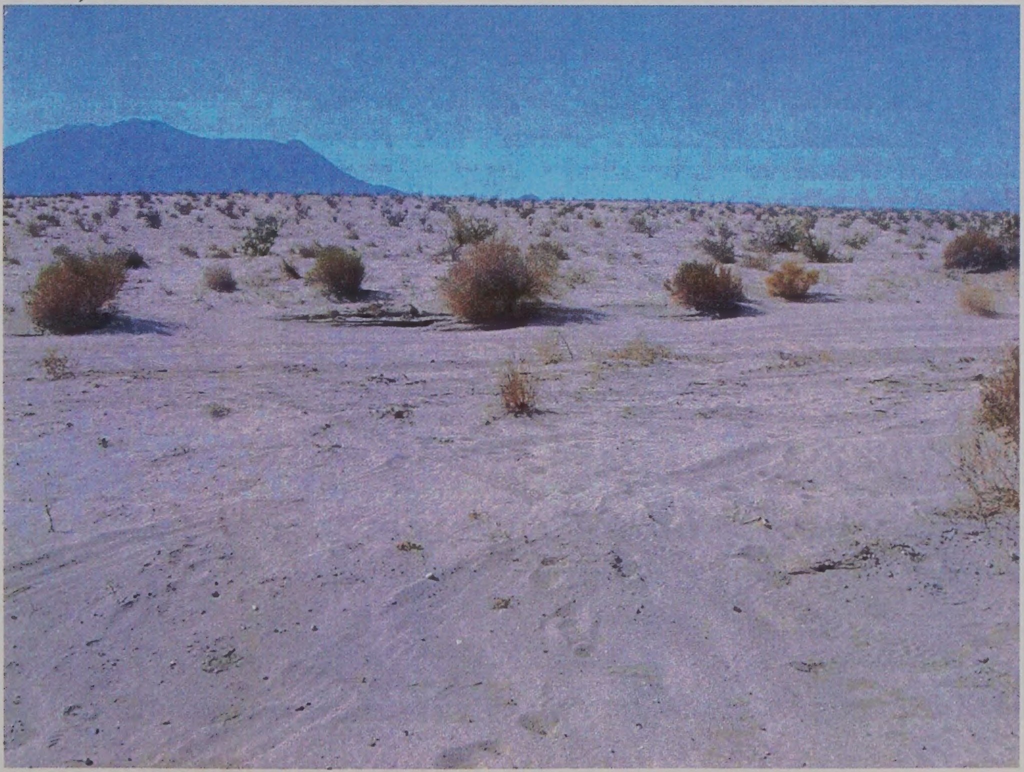
Photos were taken of the plots with a digital camera from the center of the north side and the center of the south side at bearings of 180 and 360 degrees, respectively.

UTM coordinates (NAD 83, zone 11S) for the four corners of the plots are given below the photos.

Plot 1, from south side:



Plot 1, from north side:



NW: 3617527, 617761. SW: 3617327, 617761.
SE: 3617327, 617961. NE: 3617527, 617961.

Plot 2, from south side:

Plot 2, from north side:

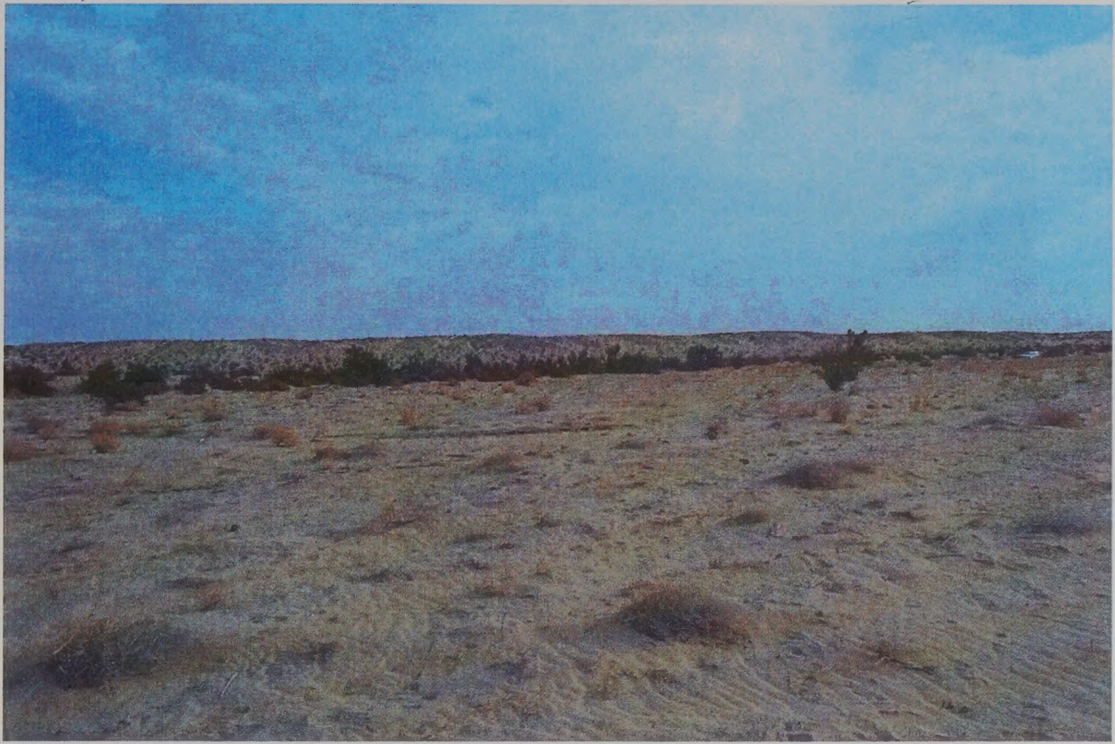
NW: 3622686, 607916. SW: 3622486, 607916.
SE: 3622486, 608116. NE: 3622686, 608116

Plot 3, from south side:

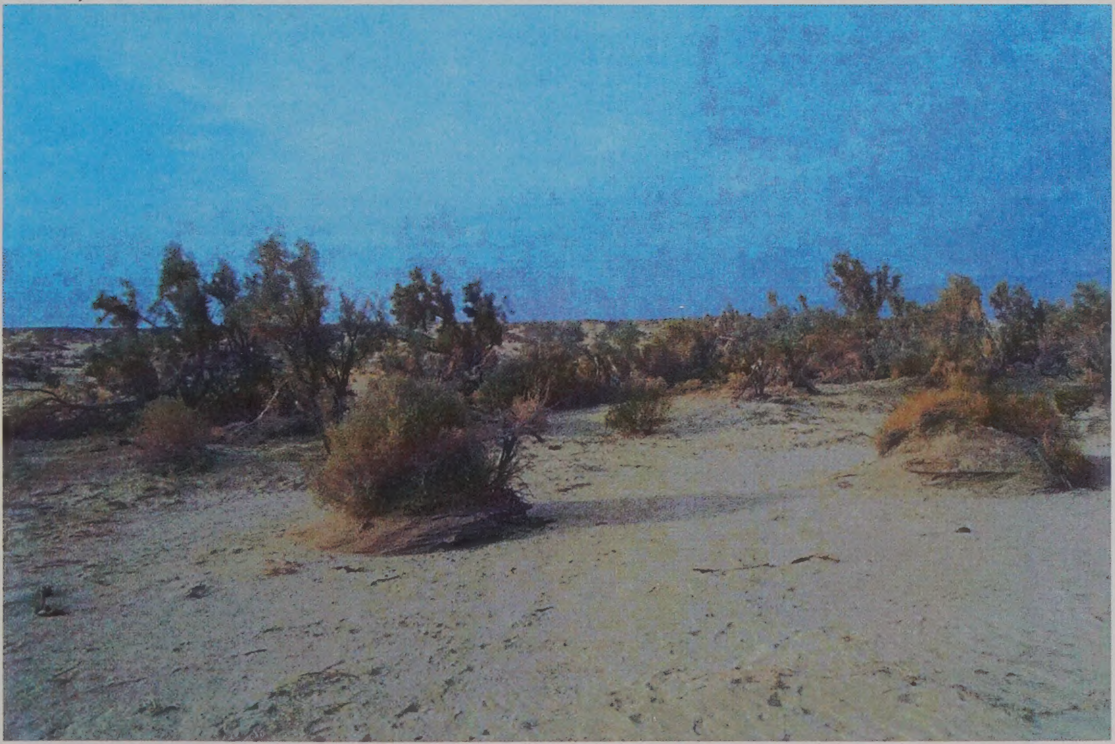
Plot 3, from north side:

NW: 3624461, 610204. SW: 3624261, 610204.
SE: 3624261, 610404. NE: 3624461, 610404.

Plot 4, from south side:



Plot 4, from north side:



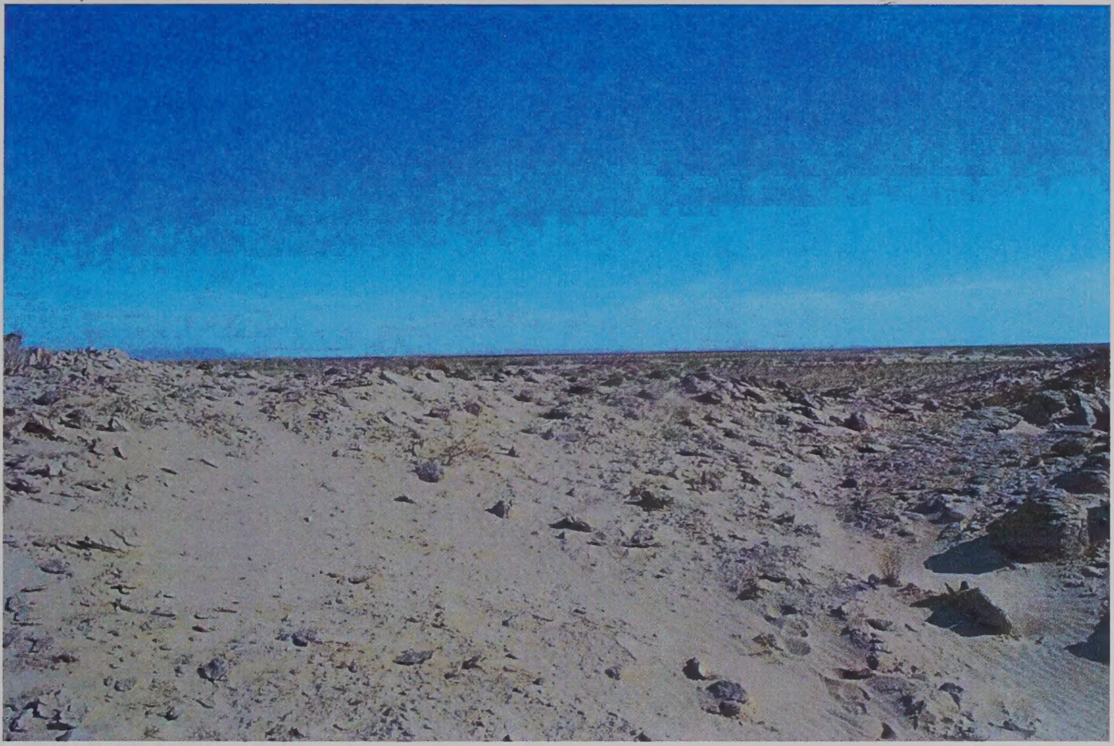
NW: 3613254, 610577. SW: 3613054, 610577.
SE: 3613054, 610777. NE: 3613254, 610777.

Plot 5, from south side:

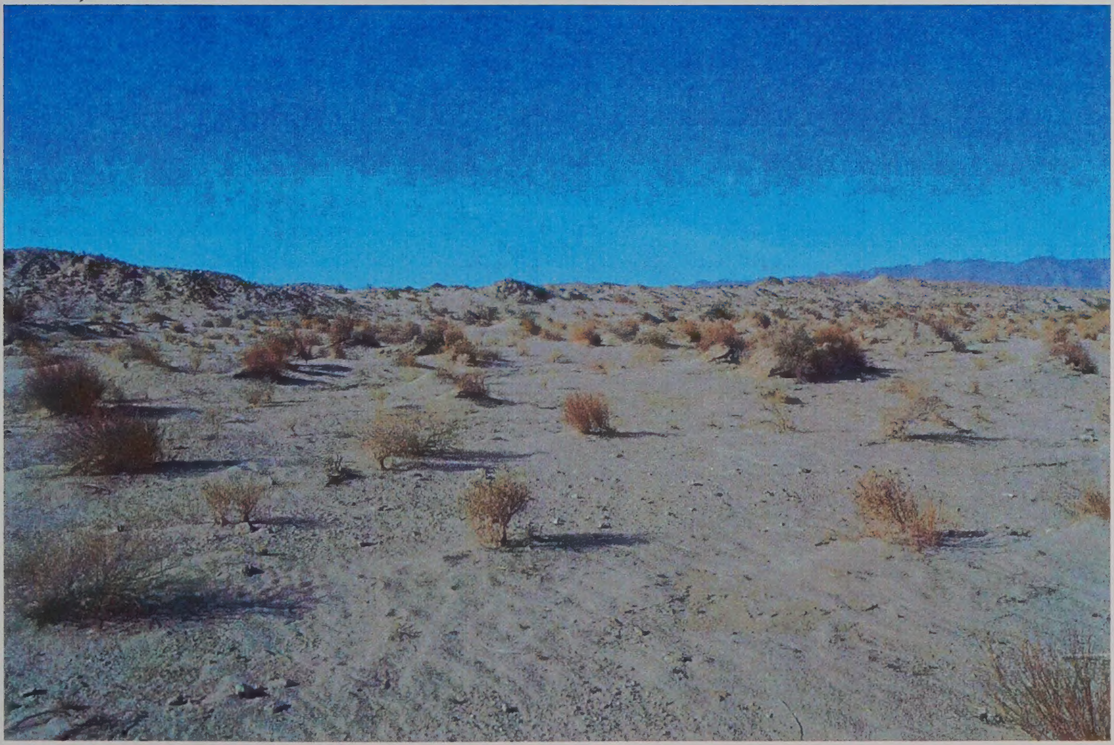
Plot 5, from north side:

NW: 3615332, 613762. SW: 3615132, 613762.
SE: 3615132, 613962. NE: 3615332, 613962.

Plot 6, from south side:

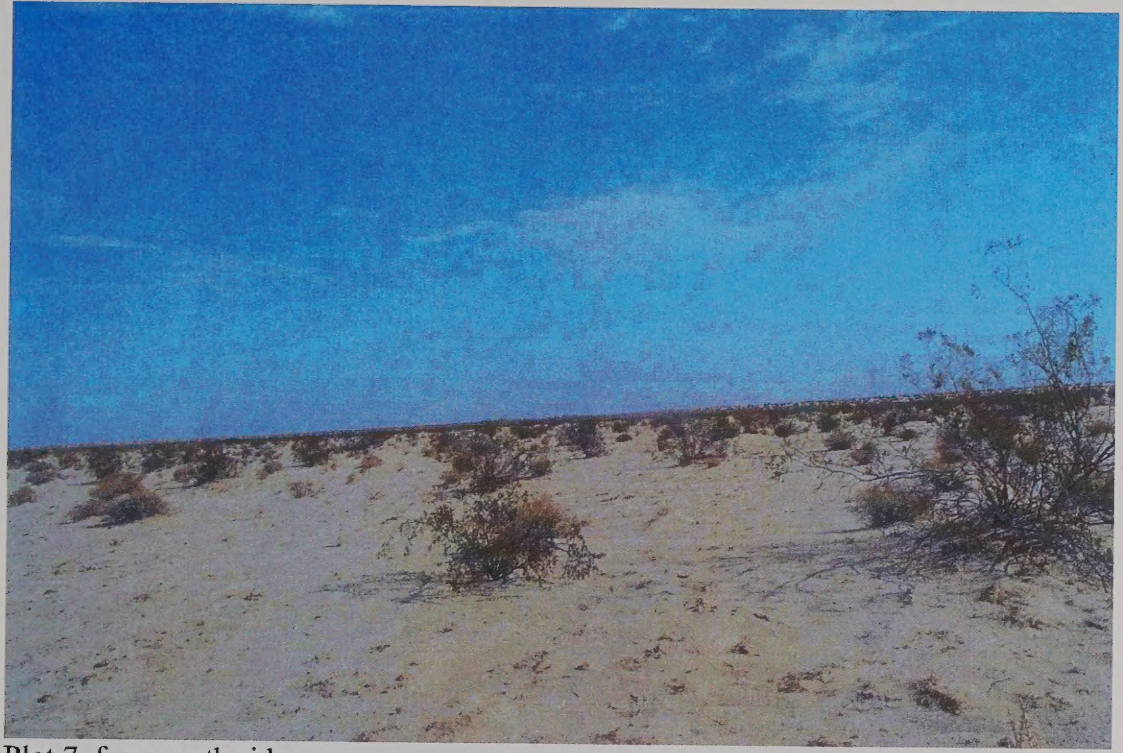


Plot 6, from north side:

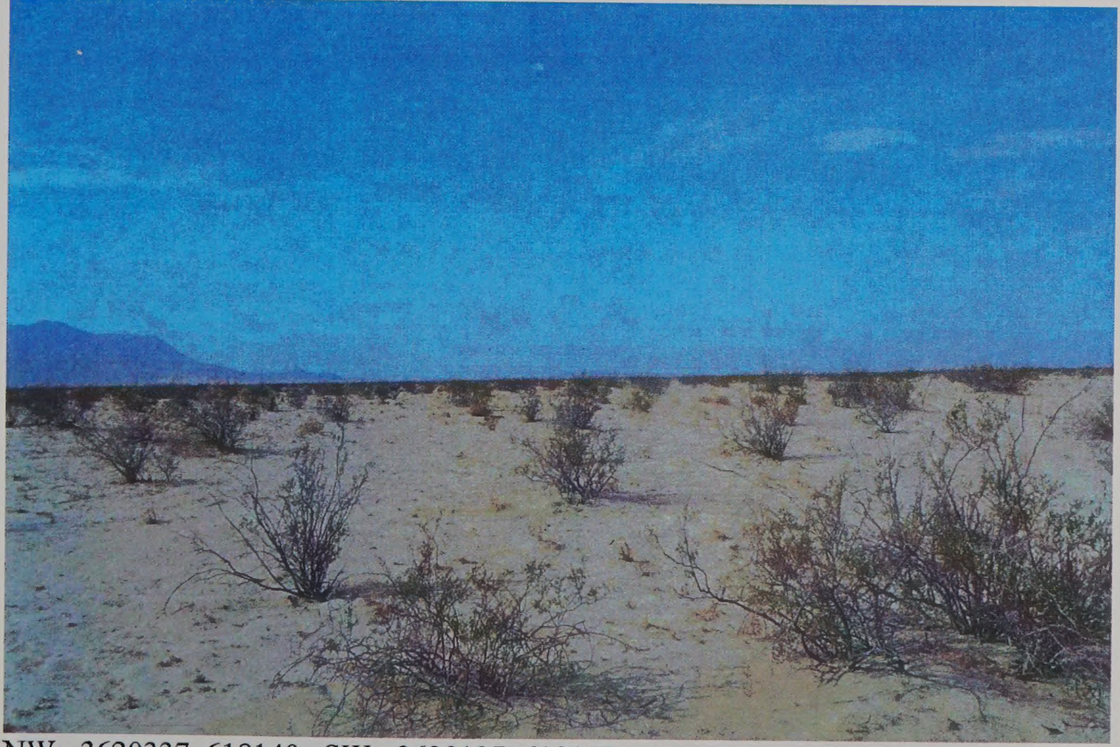


NW: 3612825, 612199. SW: 3612625, 612199.
SE: 3612625, 612399. NE: 3612825, 612399.

Plot 7, from south side:



Plot 7, from north side:



NW: 3620337, 618140. SW: 3620137, 618140.
SE: 3620137, 618340. NE: 3620337, 618340.

Plot 8, from south side:

Plot 8, from north side:

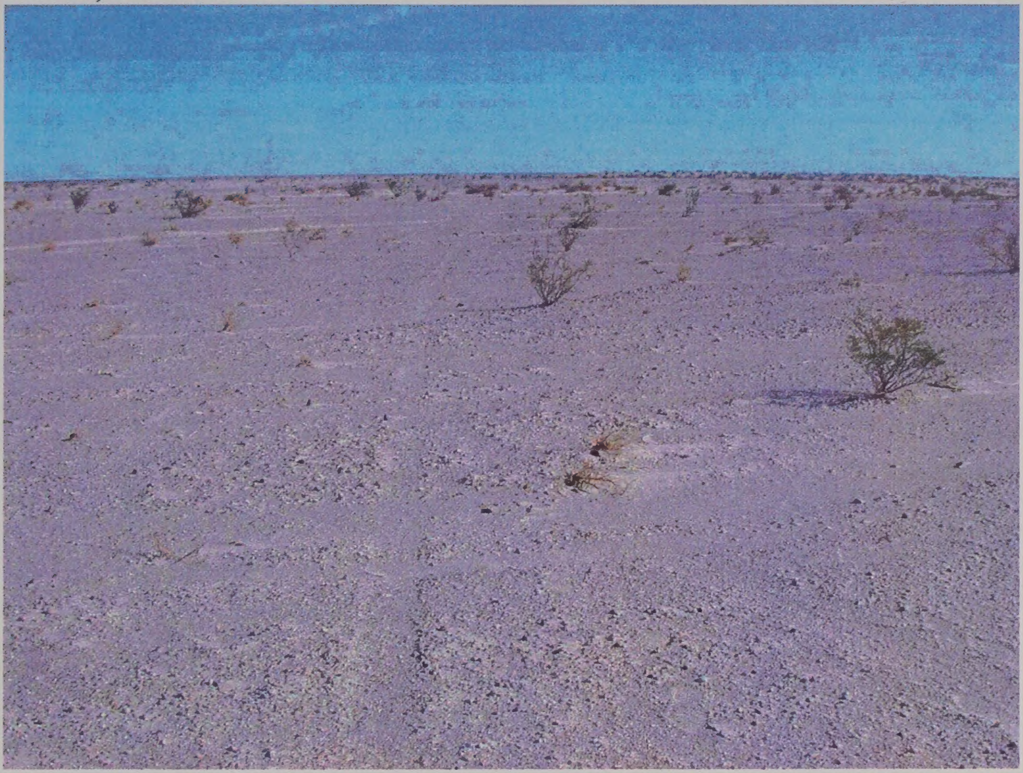
NW: 617538, 3622131. SW: 617538, 3621931.
SE: 617738, 3621931. NE: 617738, 3622131.

Plot 9, from south side:

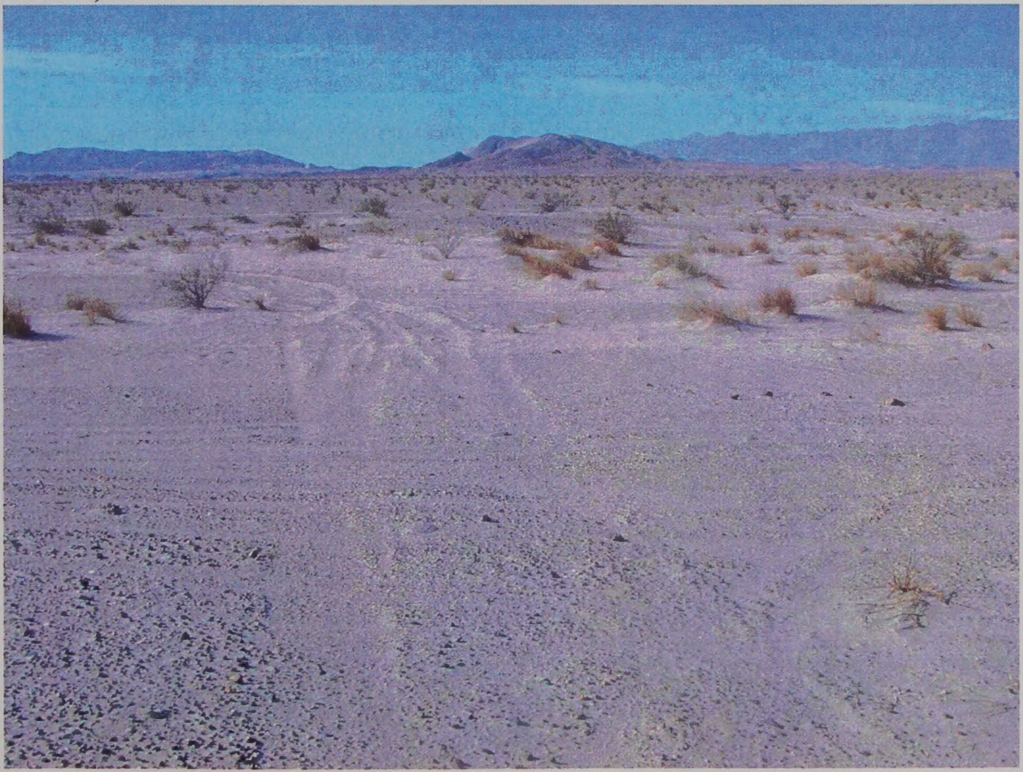
Plot 9, from north side:

NW: 3621090, 614181. SW: 3620890, 614181.
SE: 3620890, 614381. NE: 3621090, 614381.

Plot 10, from south side:

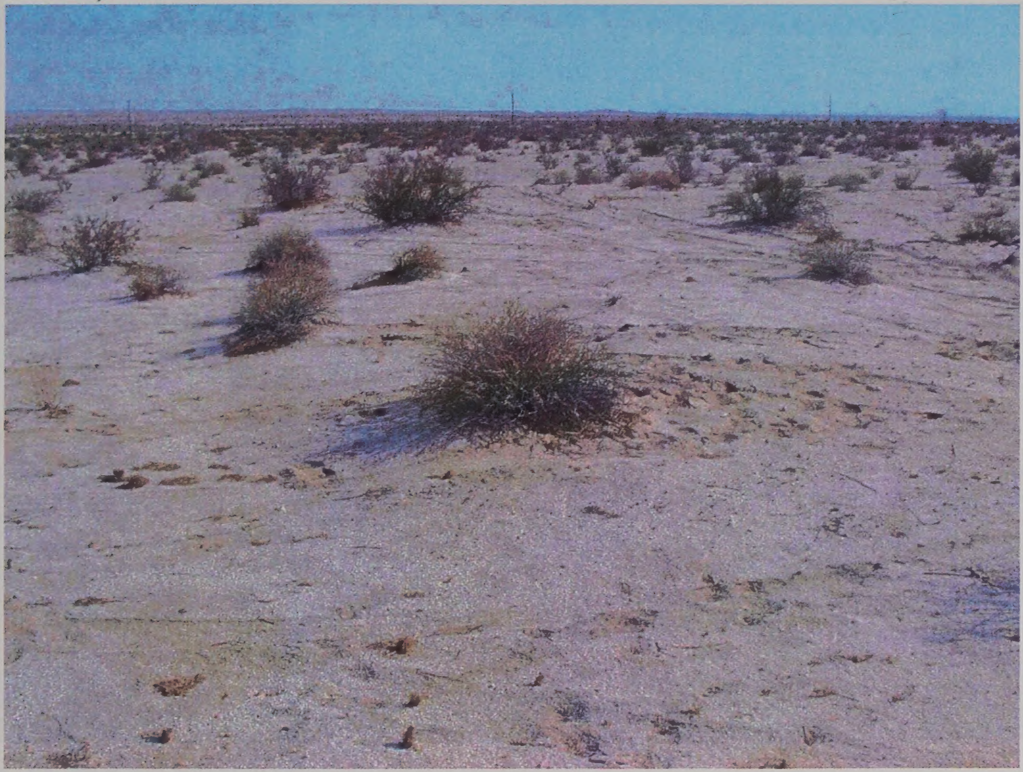


Plot 10, from north side:

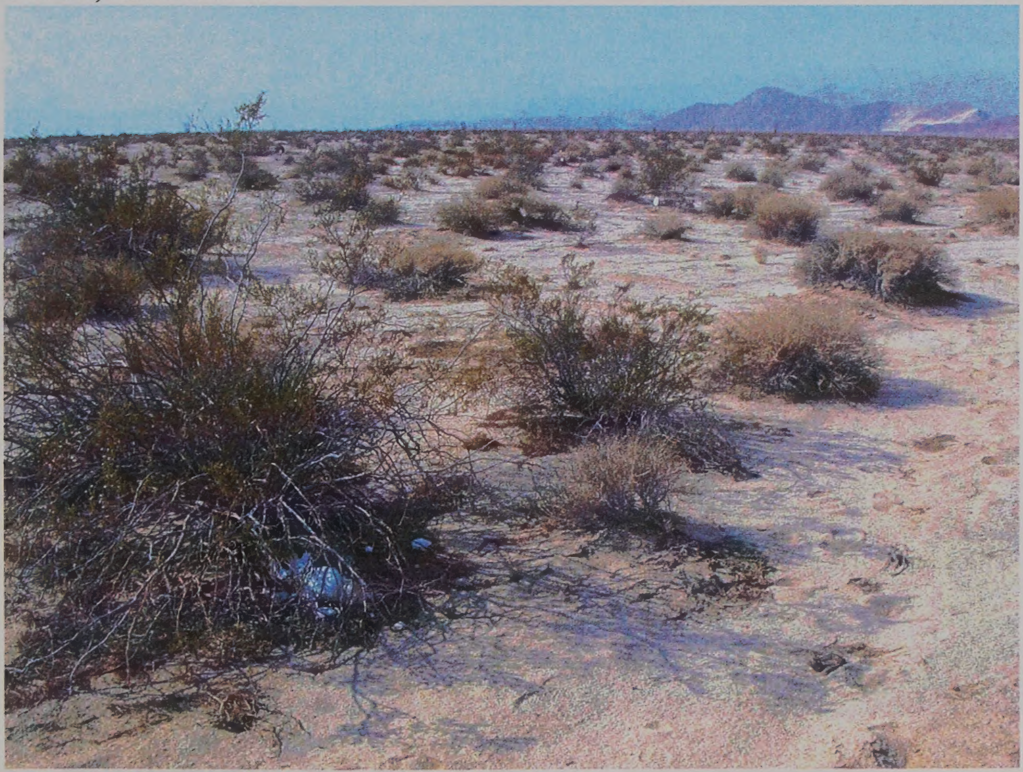


NW: 613687, 3613507. SW: 613687, 3613307.
SE: 613887, 3613307. NE: 613887, 3613507.

Plot 11, from south side:

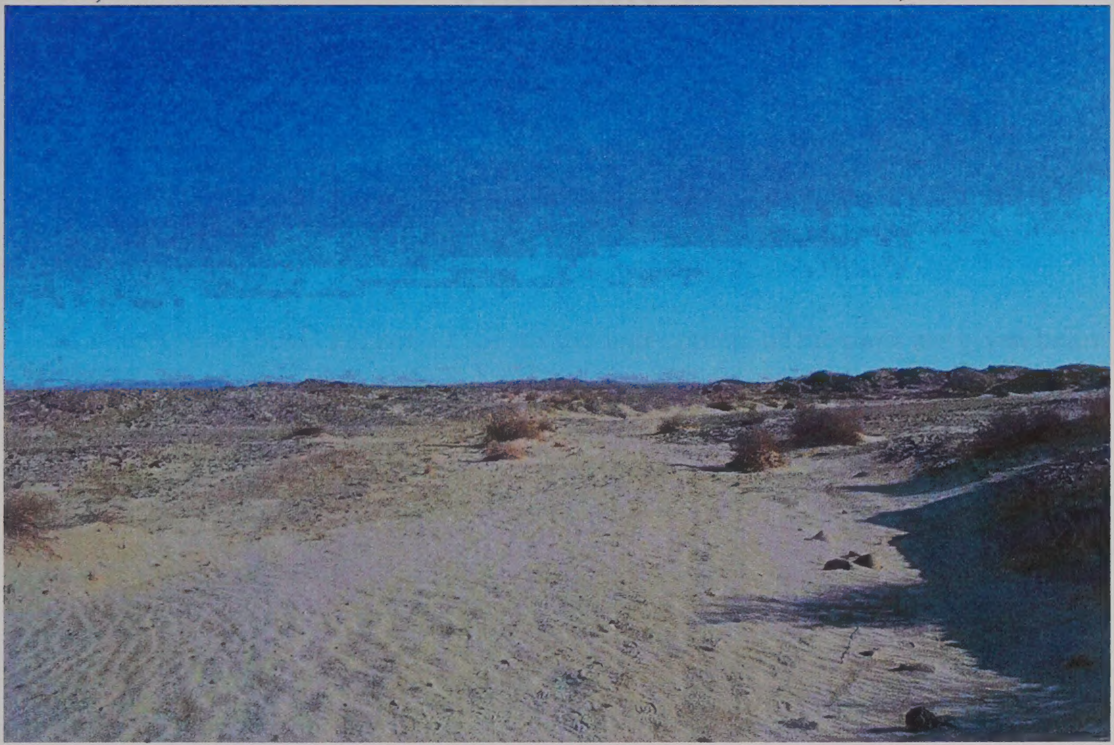


Plot 11, from north side:

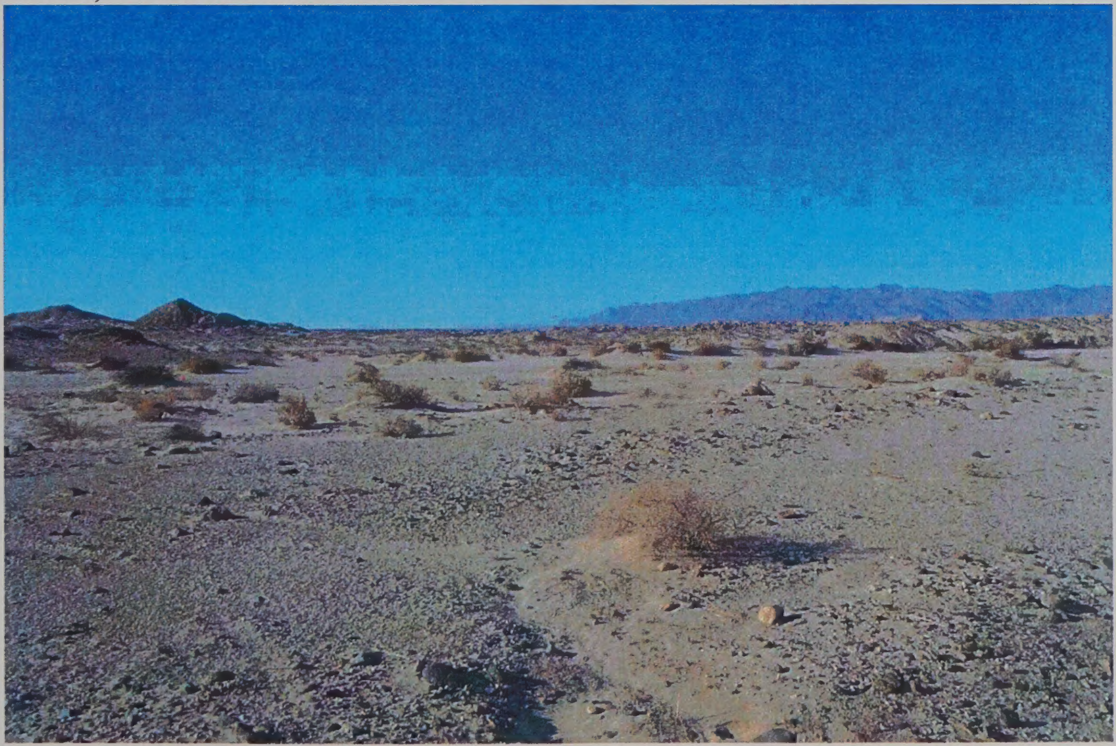


NW: 605980, 3614907. SW: 605980, 3614707.
SE: 606180, 3614707. NE: 606180, 3614907.

Plot 12, from south side:



Plot 12, from north side:



NW: 607673, 3619207. SW: 607673, 3619007.
SE: 607873, 3619007. NE: 607873, 3619207.

Appendix B

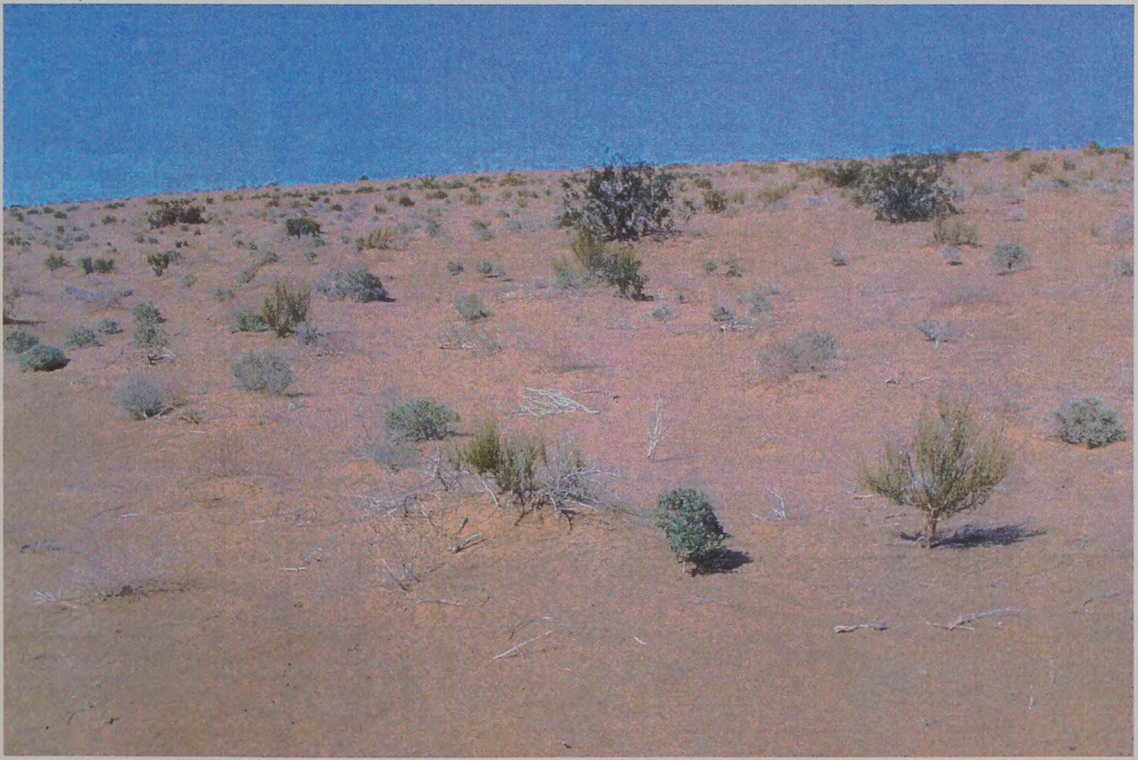
Algodones Dunes Plot Photos

Photos were taken of the plots with a digital camera from the center of the north and south sides of the plots at bearings of 180 and 360 degrees, respectively.

UTM coordinates (NAD 83, zone 11S) for the four corners of the plots are given below the photos.

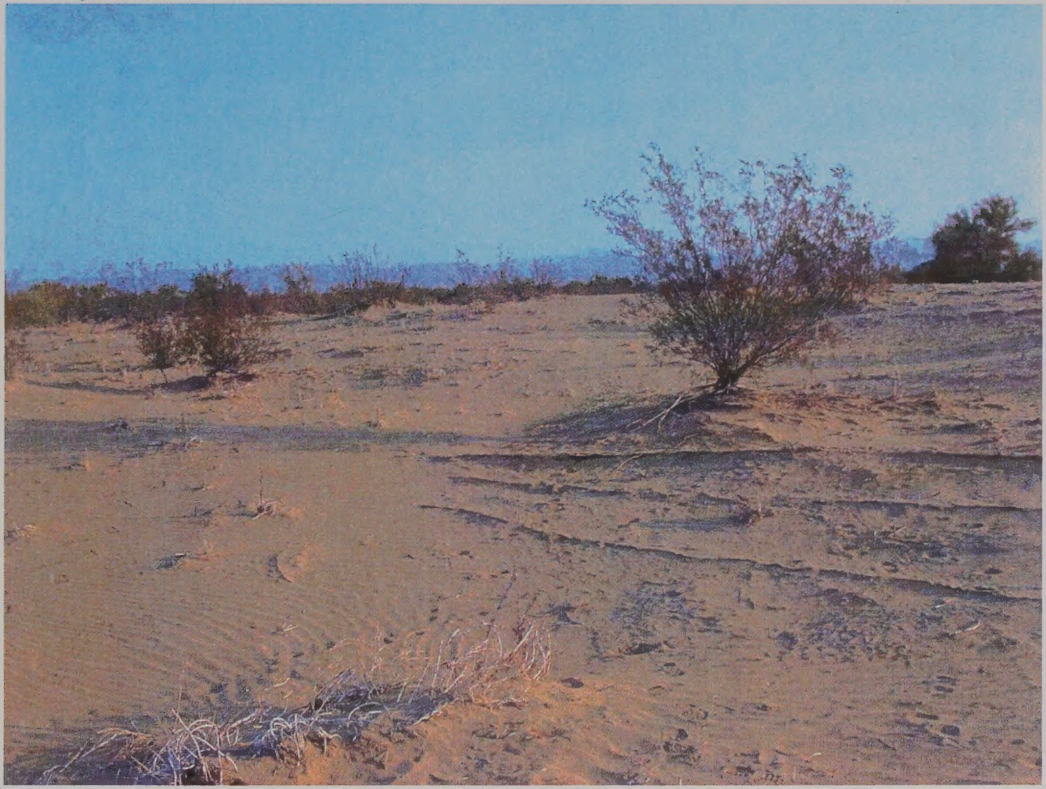
Plot 0, from north side:

Plot 0, from south side:

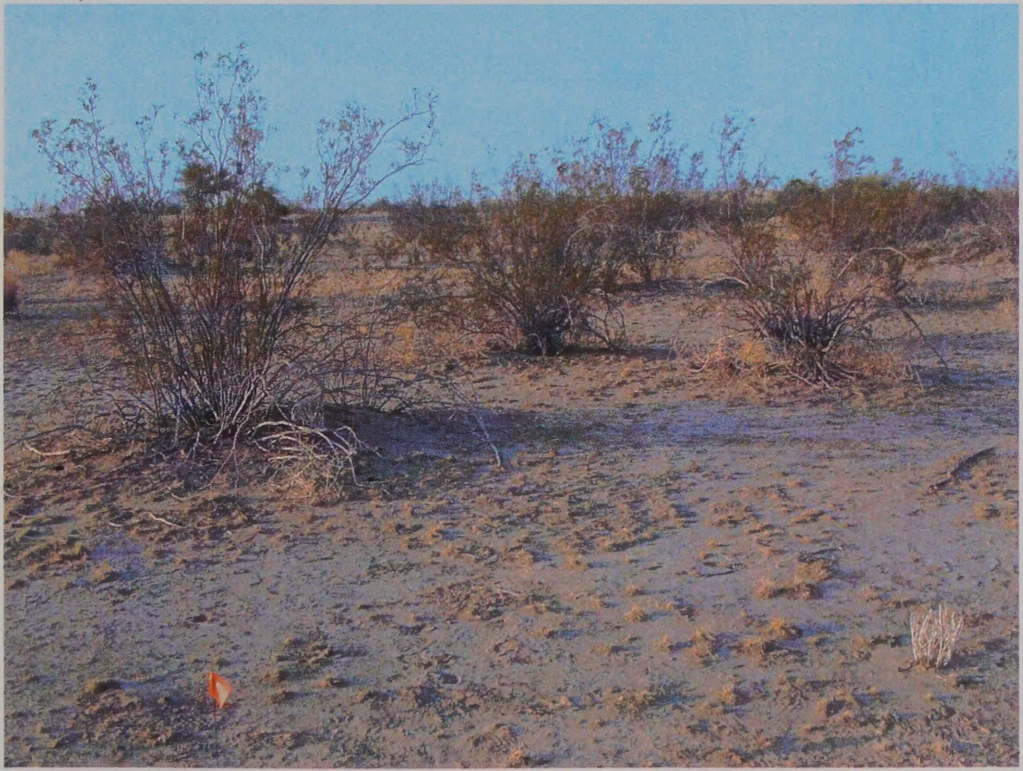


NW: 667108, 365586. SW: 667108, 3655386.
SE: 667308, 3655386. NE: 667308, 3655586.

Plot 1, from north side:

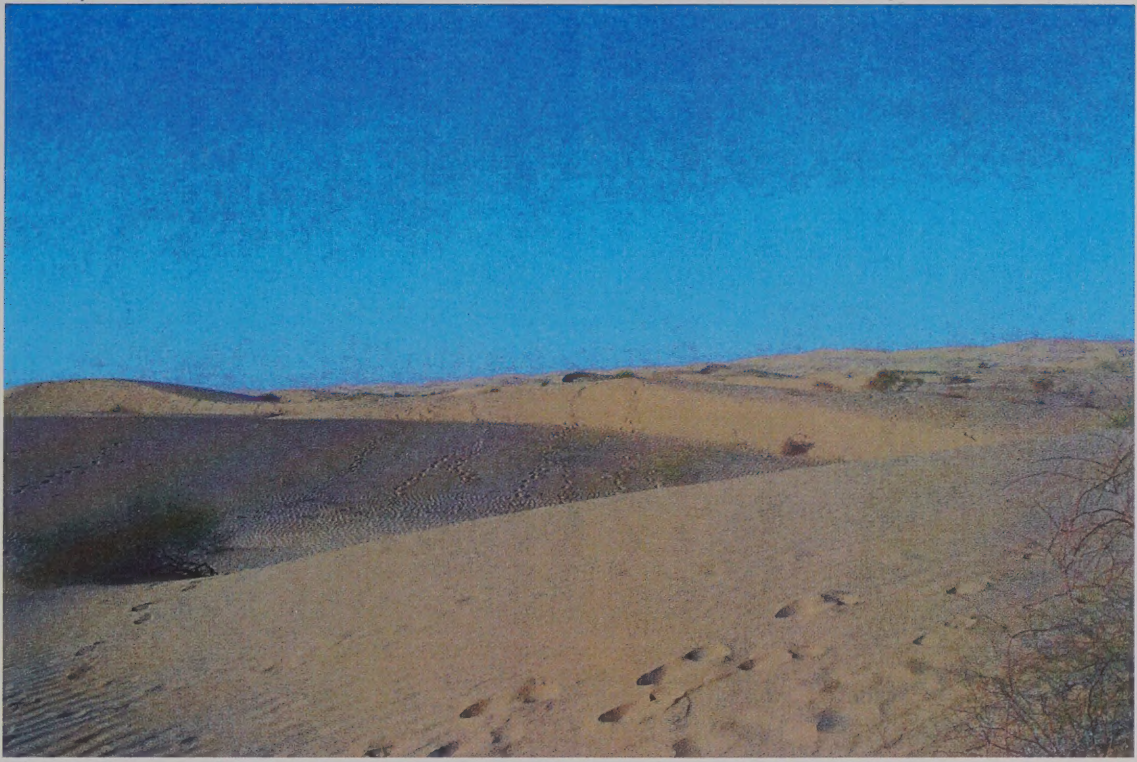


Plot 1, from south side:

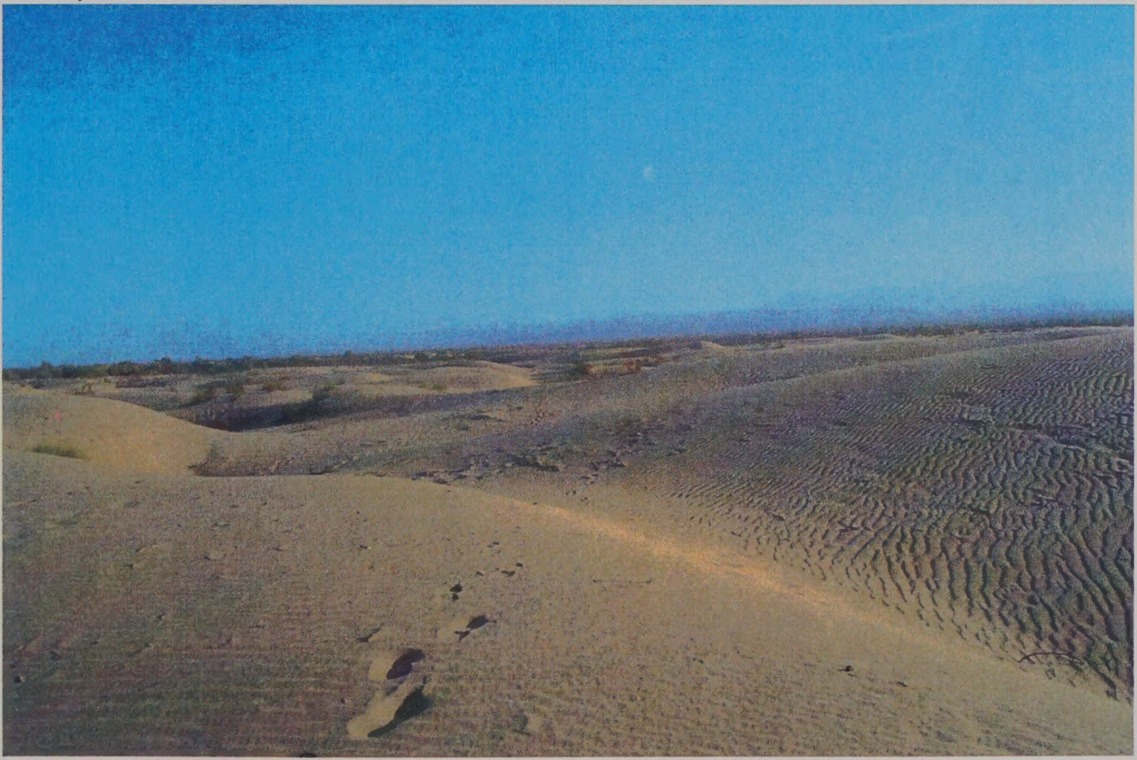


NW: 677271, 3653771. SW: 677271, 3653571.
SE: 677471, 3653571. NE: 677471, 3653771.

Plot 3, from north side:

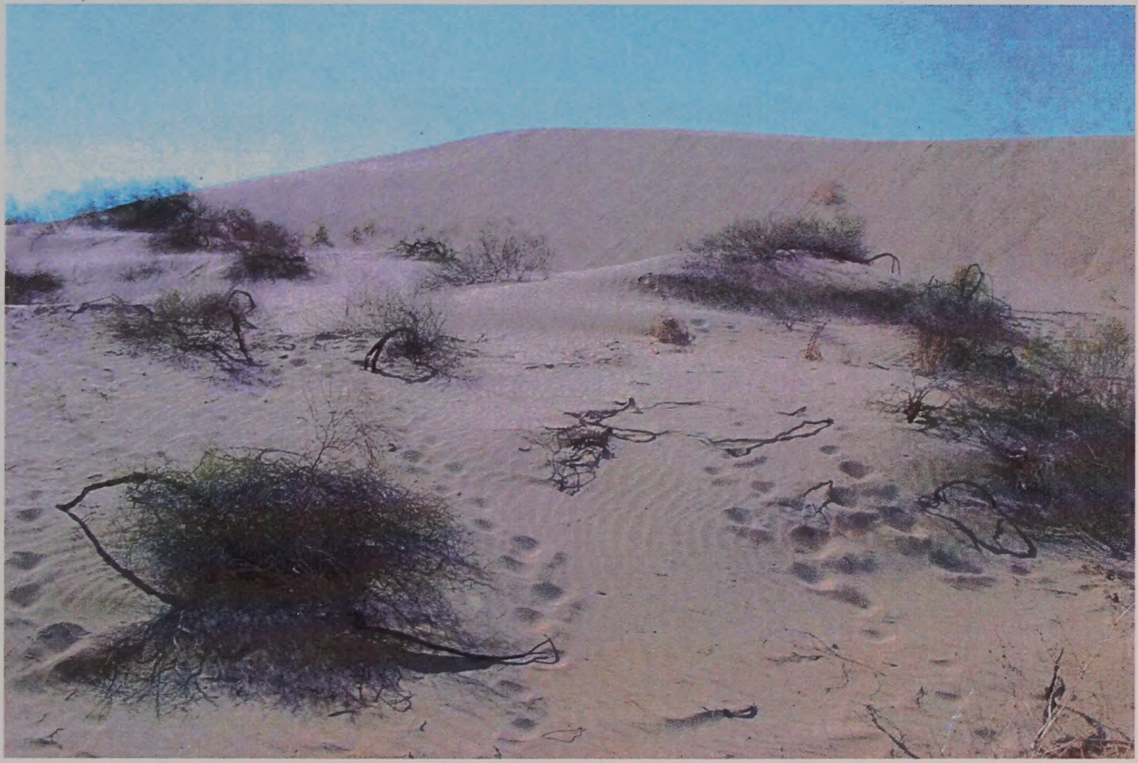


Plot 3, from south side:

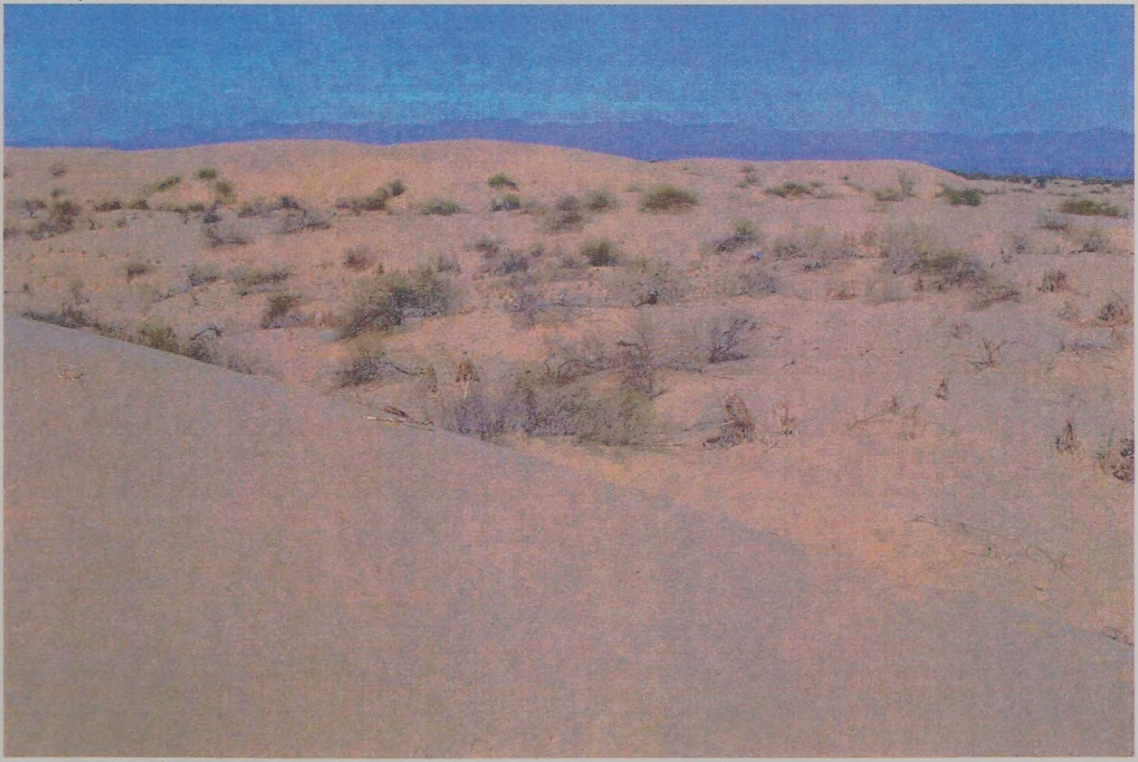


NW: 3660928, 664613. SW: 3660928, 664413.
SE: 3661128, 664413. NE: 3661128, 664613.

Plot 4, from north side:

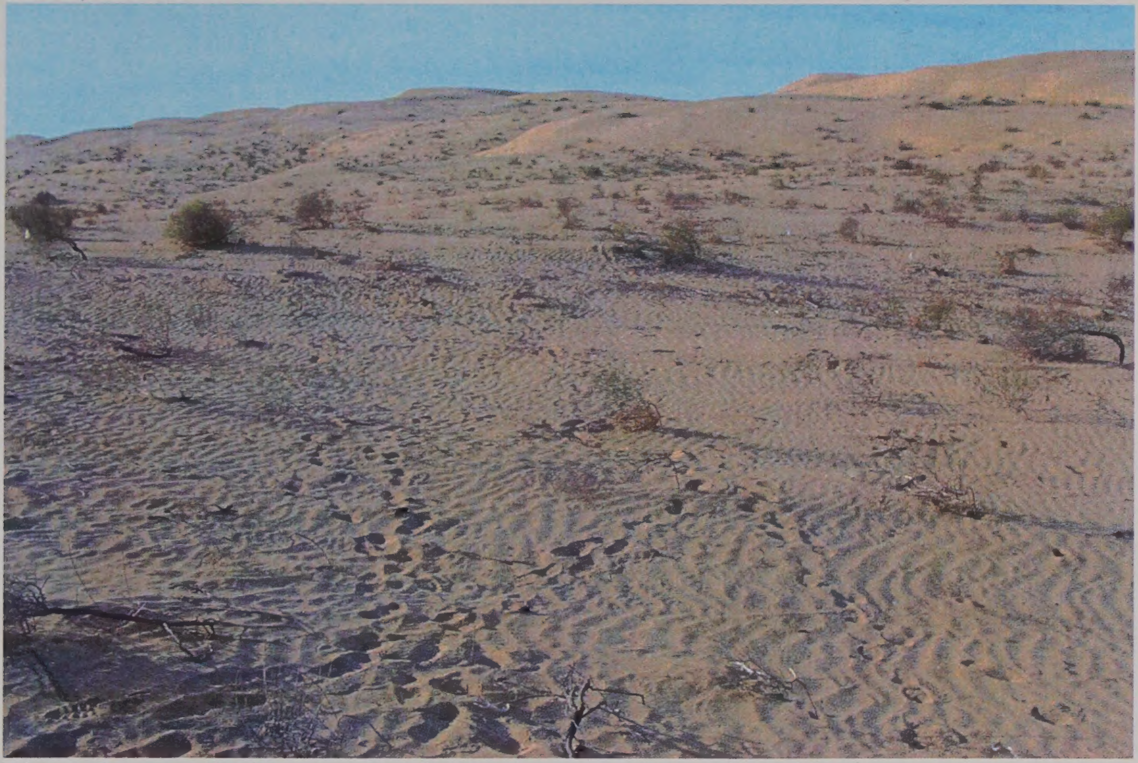


Plot 4, from south side:

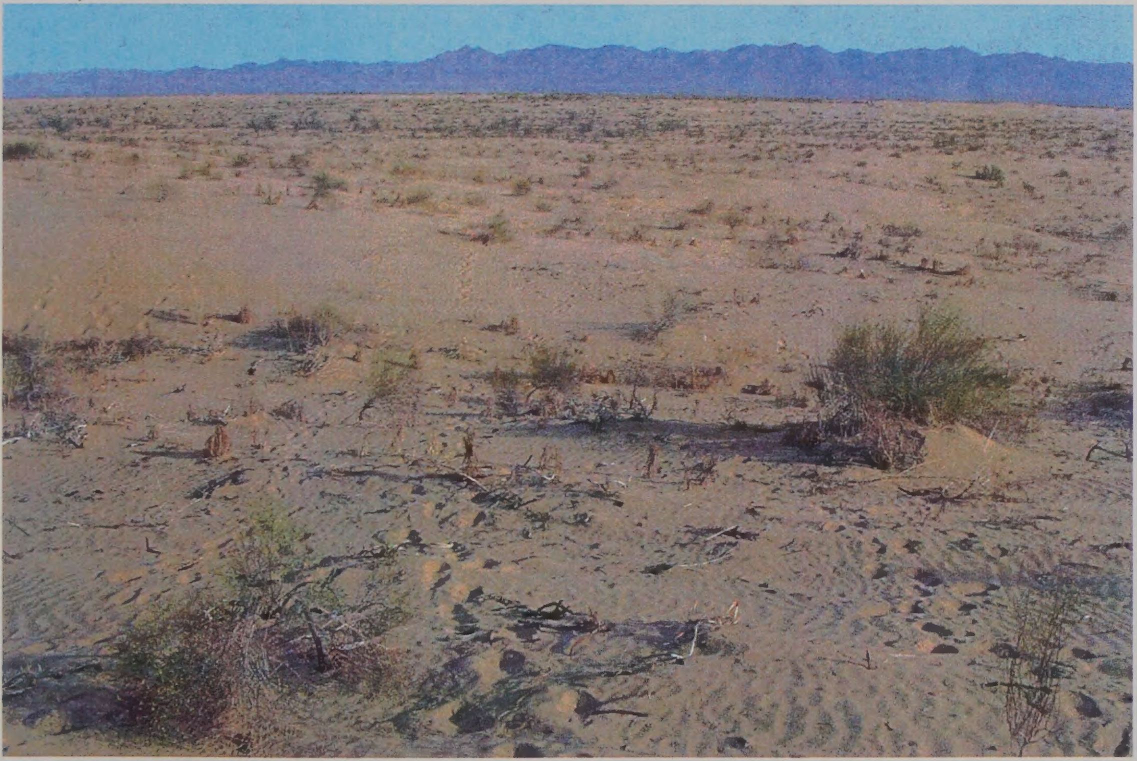


NW: 667936, 3658131. SW: 667936, 3657931.
SE: 668136, 3657931. NE: 668136, 3658131.

Plot 5, from north side:

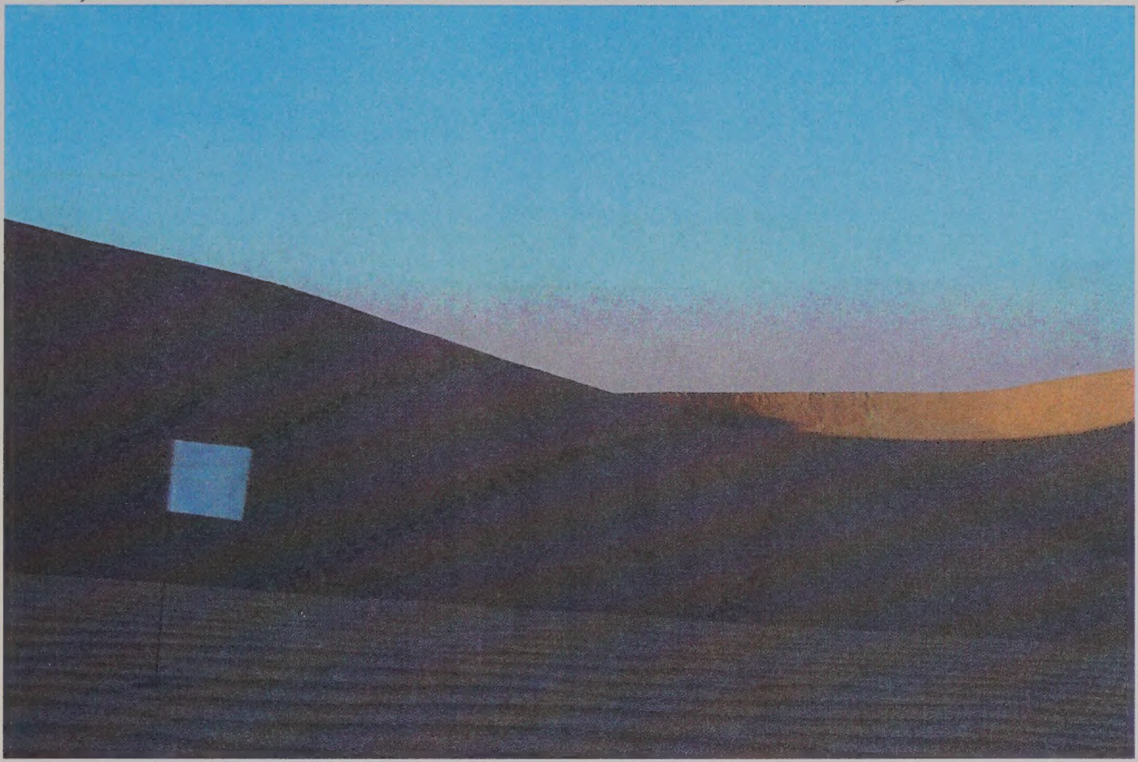


Plot 5, from south side:



NW: 666016, 3658635. SW: 666016, 3658435.
SE: 666216, 3658435. NE: 666216, 3658635.

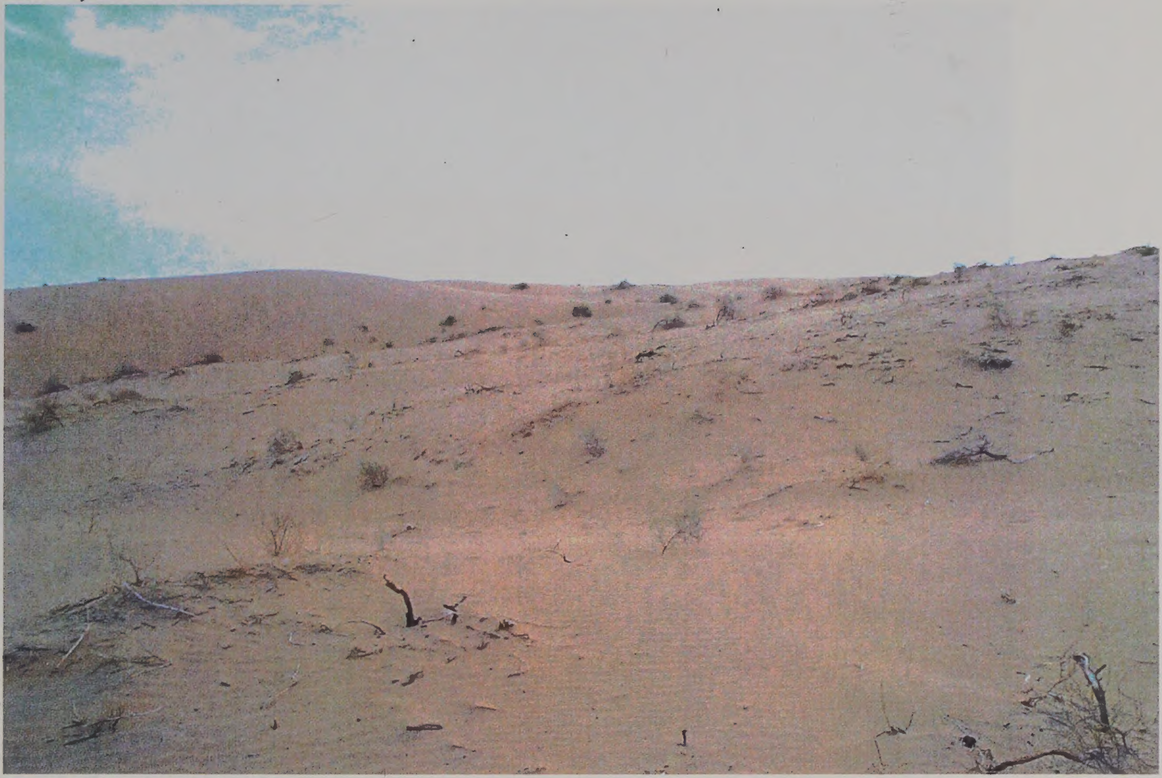
Plot 6, from north side:



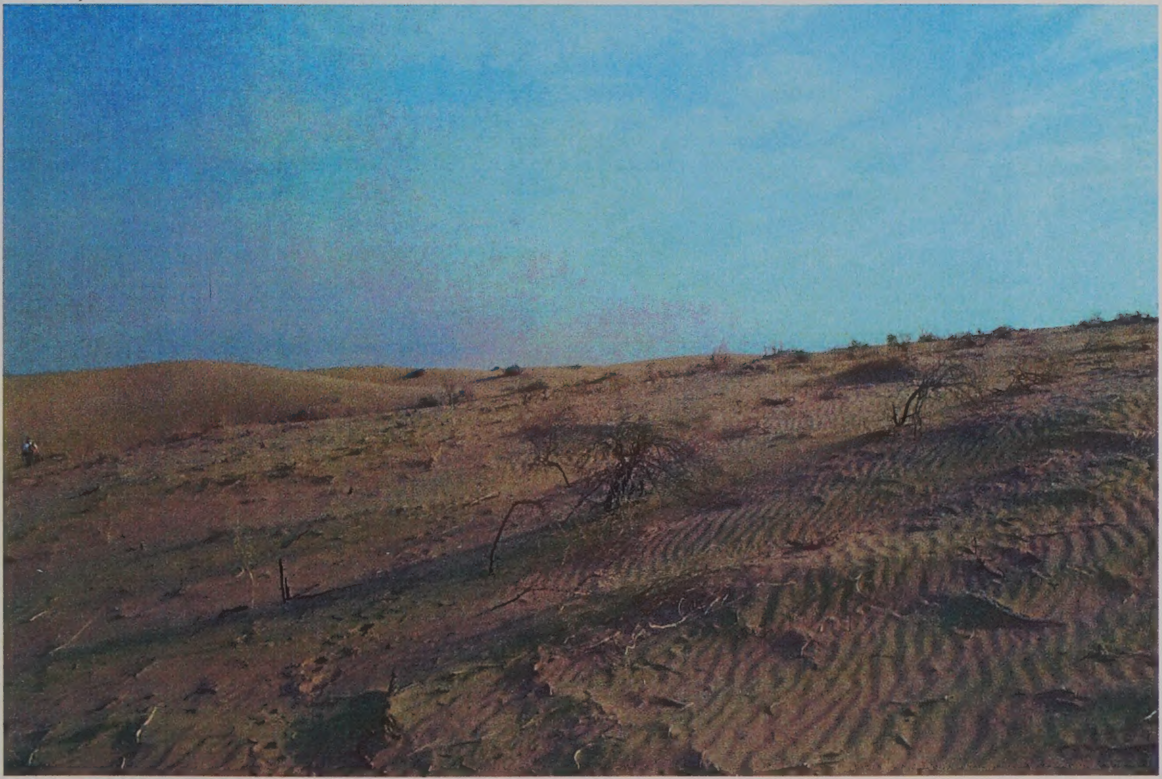
Plot 6, from south side:

NW: 676543, 3648461. SW: 676543, 3648261.
SE: 676743, 3648261. NE: 676743, 3648461.

Plot 7, from north side:

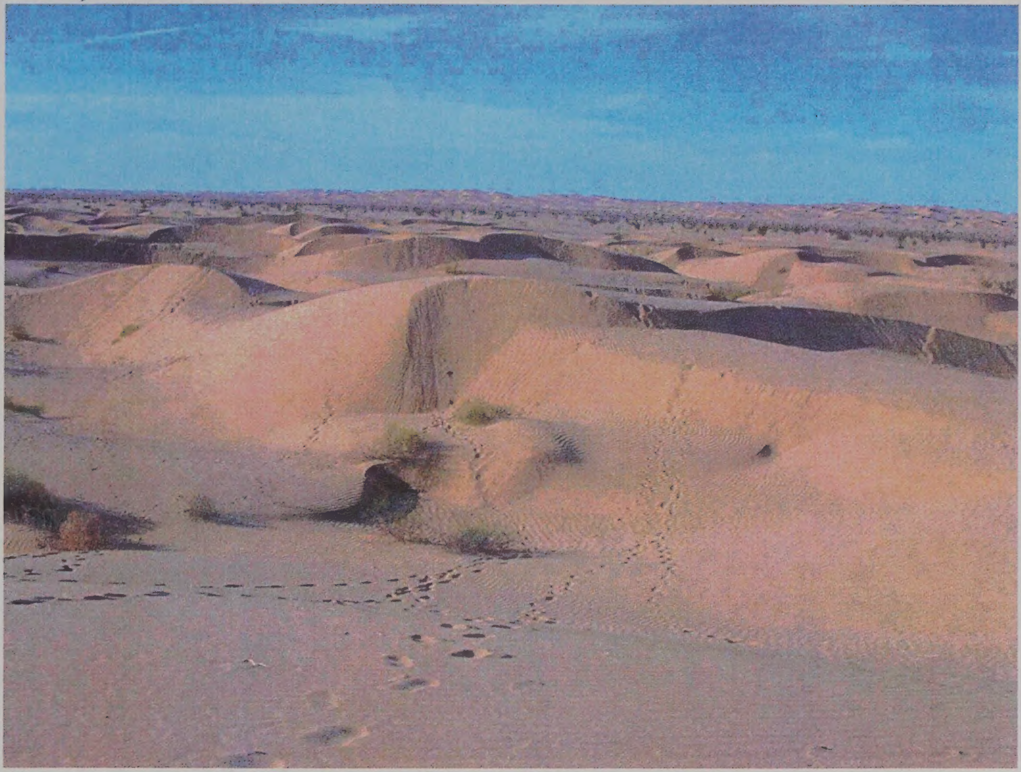


Plot 7, from south side:

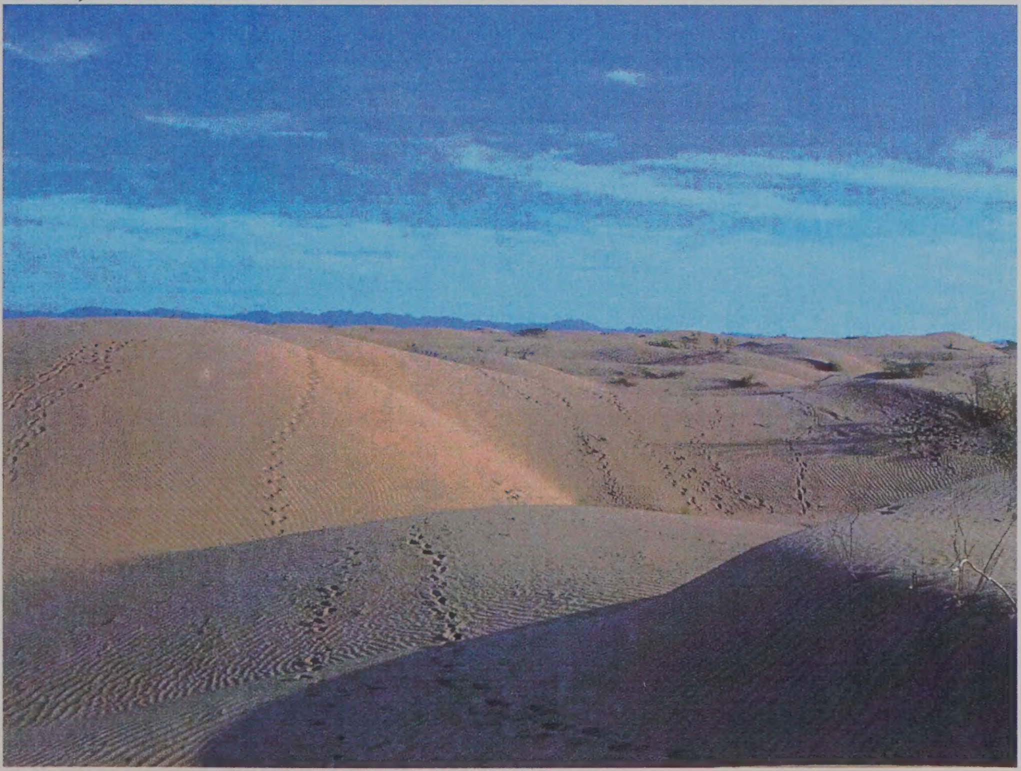


NW: 677340, 3643363. SW: 677140, 3643363.
SE: 677140, 3643563. NE: 677340, 3643563.

Plot 9, from north side:

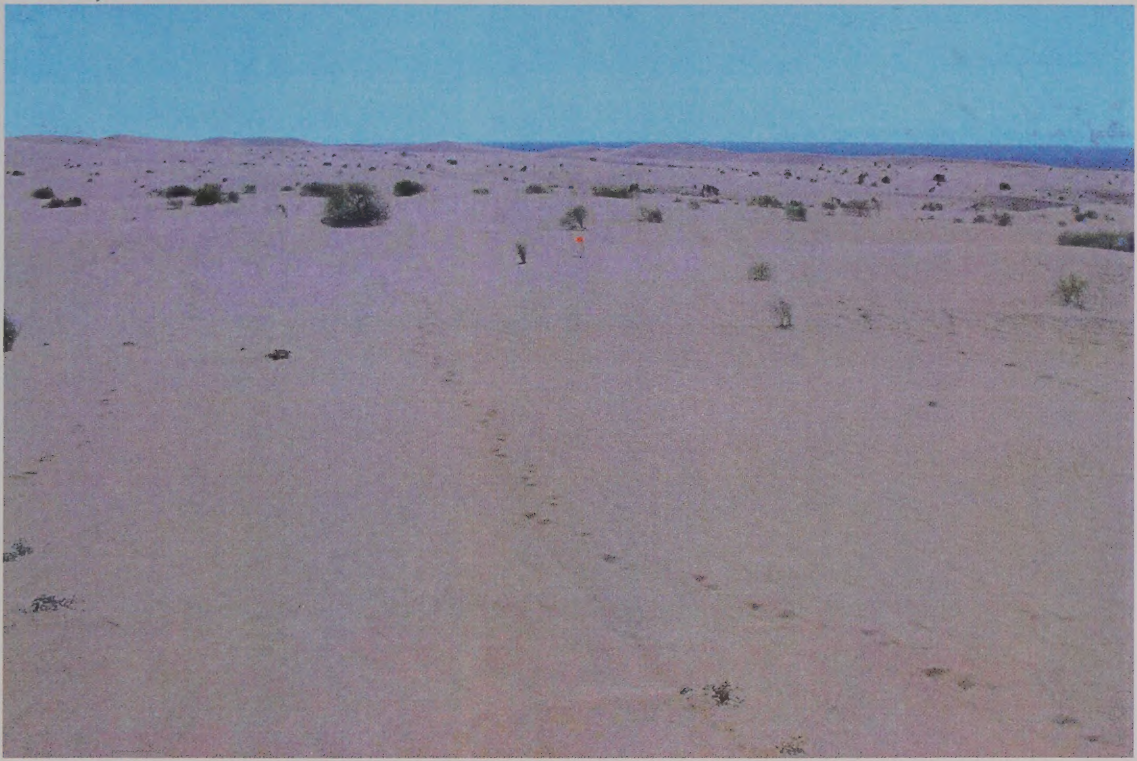


Plot 9, from south side:

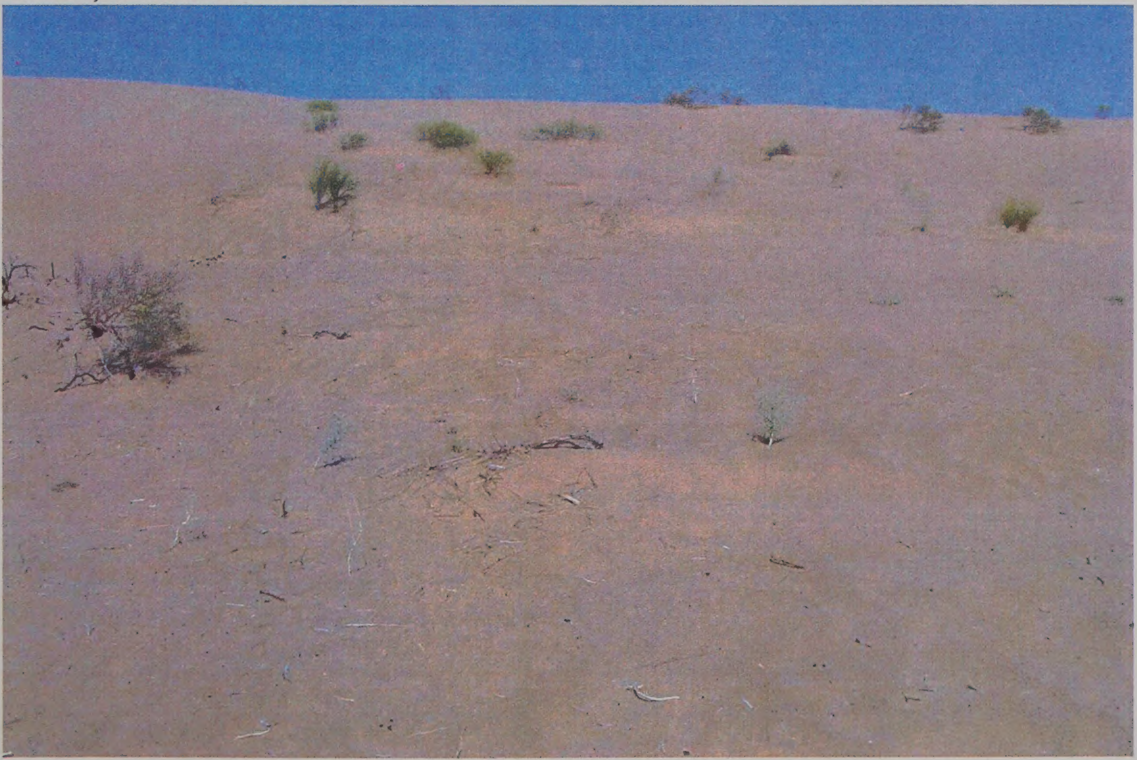


NW: 686952, 3643970. SW: 686952, 3643770.
SE: 687152, 3643970. NE: 687152, 3643970.

Plot 10, from north side:

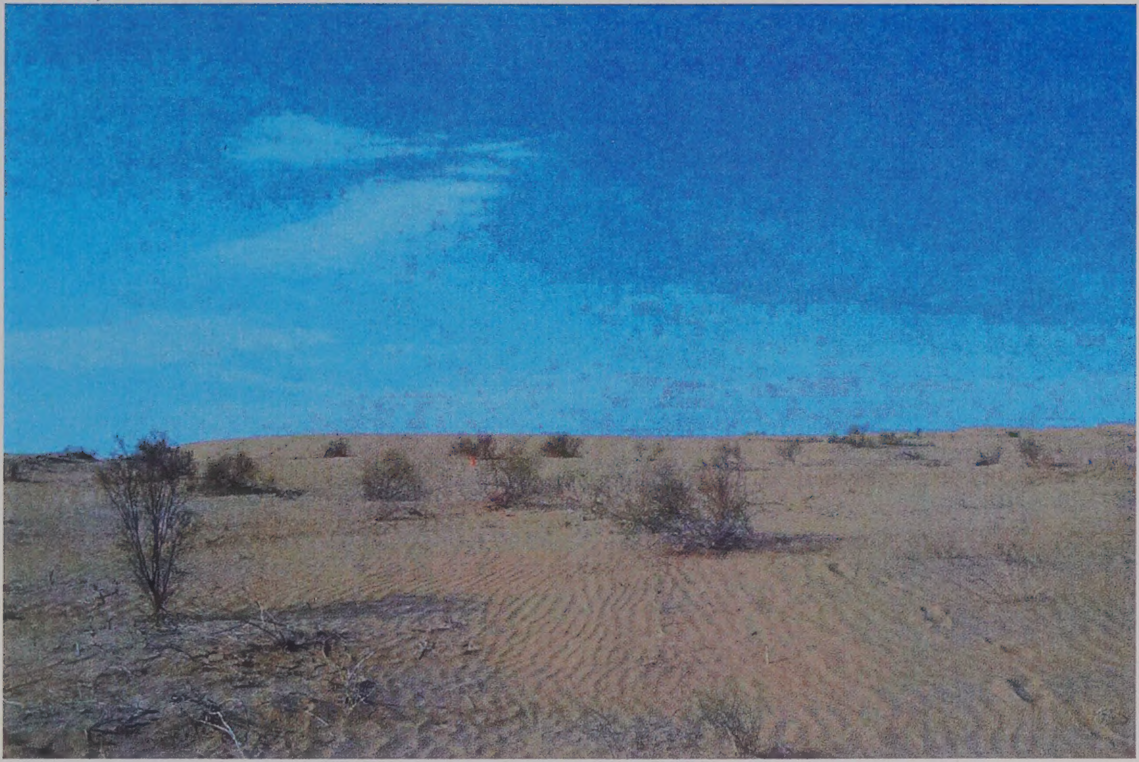


Plot 10, from south side:

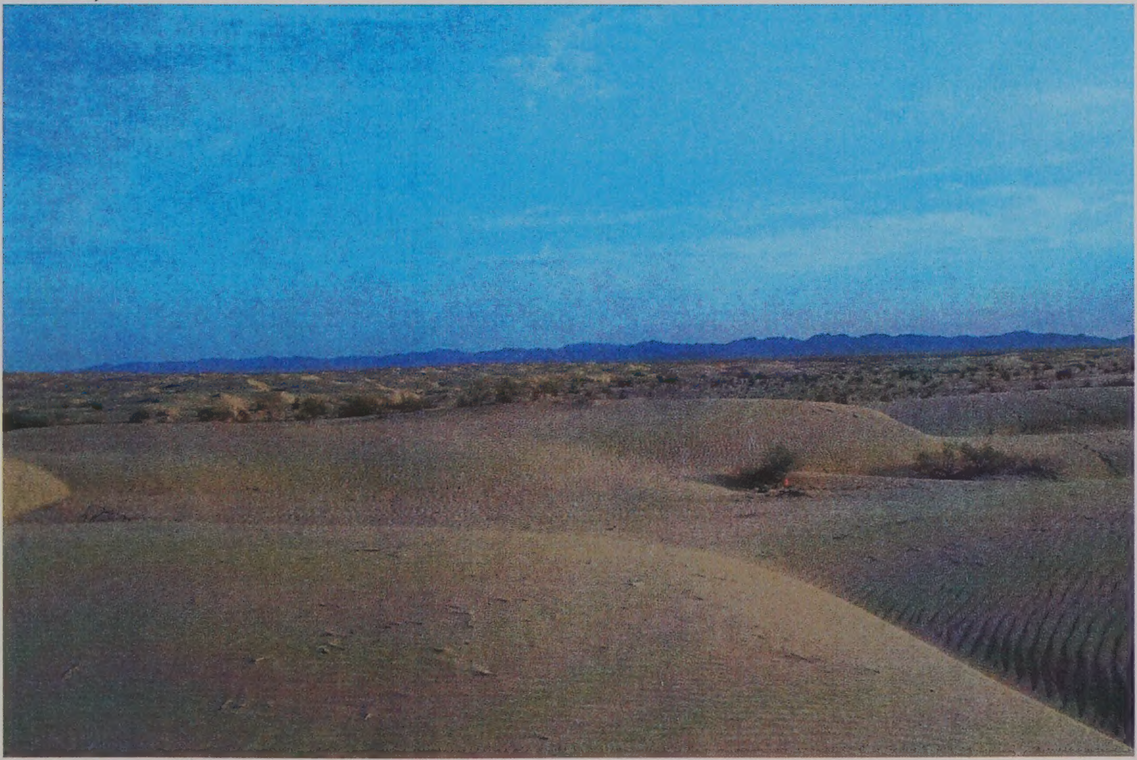


NW: 672619, 3649692. SW: 672619, 3649492.
SE: 672819, 3649492. NE: 672819, 3649692.

Plot 12, from north side:

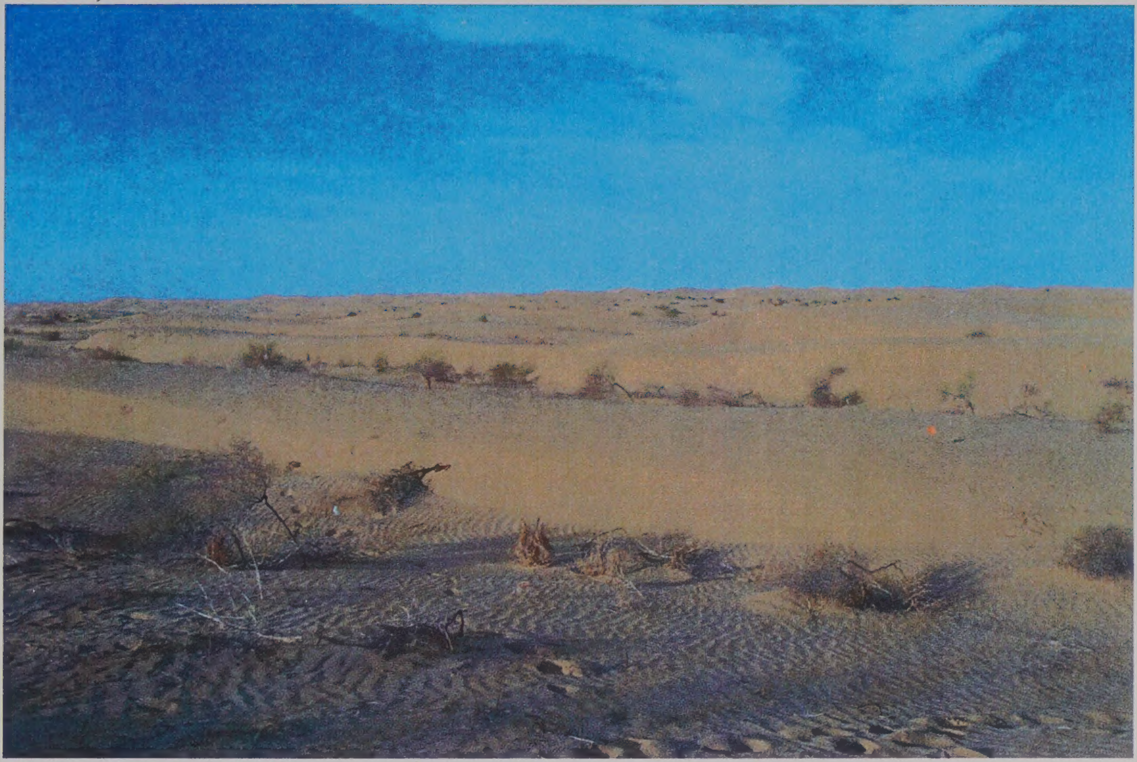


Plot 12, from south side:

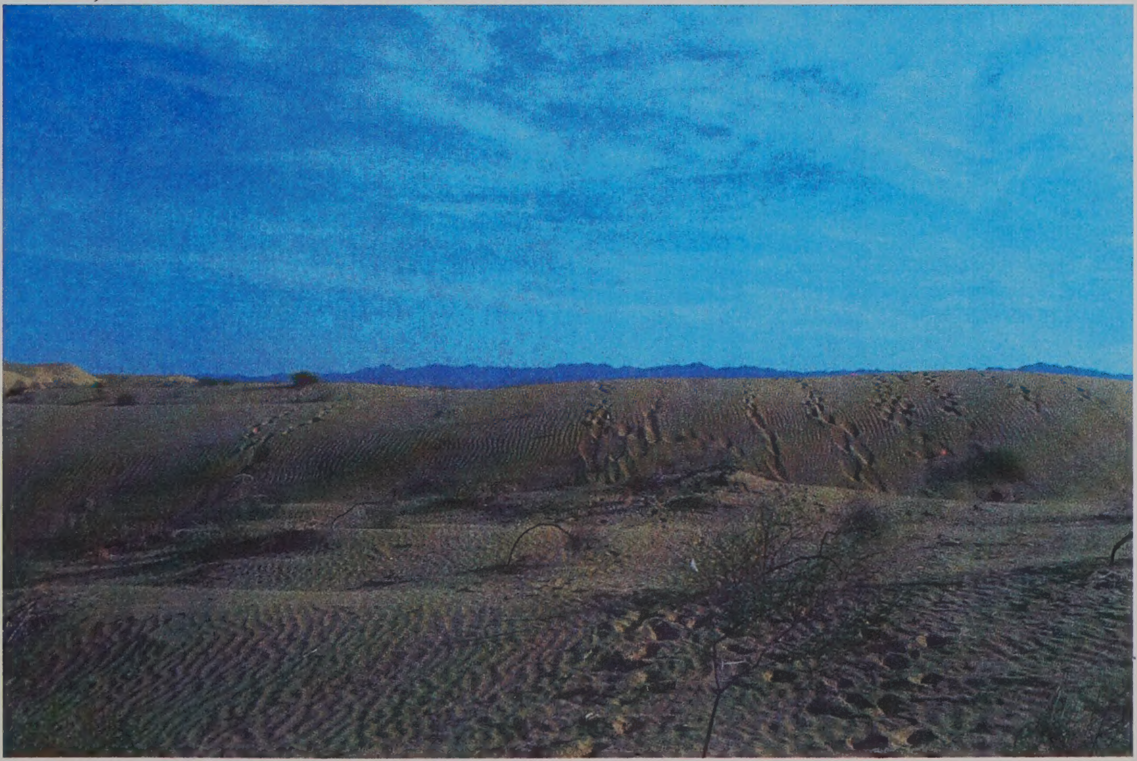


NW: 683056, 3645346. SW: 683056, 3645146.
SE: 683256, 3645146. NE: 683256, 3645346.

Plot 13, from north side:



Plot 13, from south side:



NW: 670031, 3657044. SW: 670031, 3656849.
SE: 670231, 3656849. NE: 670230, 3657049.